



HIGH ENERGY ASTROPHYSICS PROGRAM

(HEAP)

NASA CONTRACT

NAS 5 – 32490

Final Technical Report

April 1, 1998 through September 30, 1998

UNIVERSITIES SPACE RESEARCH ASSOCIATION

(USRA)

**David V. Holdridge
Project Manager**



UNIVERSITIES SPACE RESEARCH ASSOCIATION

High Energy Astrophysics Program

7501 Forbes Blvd., Suite 206
Seabrook, MD 20706-2253
Tel: (301) 805-8396
Fax: (301) 805-8466

NASA/GODDARD Space Flight Center
Mail Code 610.3
Greenbelt, MD 20771
Tel: (301) 286-5057

Member Institutions

Alabama A&M University
Alabama, University of
(in Huntsville)
Alaska, University of
Arizona, University of
Arizona State University
Boston College
Boston University
Brandeis University
British Columbia, University of
Brown University
California, University of
(Berkeley)
California, University of
(Los Angeles)
California, University of
(San Diego)
California, University of
(Santa Barbara)
Case Western Reserve University
Chicago, University of
Colorado, University of
(Boulder)
Connecticut, University of
Cornell University
Delaware, University of
Denver, University of
Florida State University
Florida, University of
(Gainesville)
Georgetown University
George Washington University
Georgia Institute of Technology
Hampton University
Harvard University
Hawaii, University of, (Manoa)
Houston, University of
Illinois, University of
(Urbana -Champaign)
Indiana University
Iowa State University
Iowa, University of
Johns Hopkins University
Kansas, University of
Lehigh University
Louisiana State University
Maryland, University of
(College Park)
Massachusetts Institute of Technology
Michigan, University of
Michigan Technological University
Minnesota, University of
New Hampshire, University of
New Mexico, State University of
New York, State University of
(Buffalo)
New York, State University of
(Stonybrook)
New York University
North Carolina A&T University
North Carolina State University
Northwestern University
Ohio State University
Old Dominion University
Pennsylvania State University
Pittsburgh, University of
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rice University
Rochester, University of
Rockefeller University
Sheffield, University of
Southern California, University of
Stanford University
Tel-Aviv University
Tennessee, University of
Texas A&M University
Texas, University of, (Austin)
Texas, University of (Dallas)
Texas, University of
(Medical Branch, Galveston)
Toronto, University of
Utah State University
Vanderbilt University
Virginia Polytechnic Institute
and State University
Virginia, University of
Washington, University of
Washington University (St. Louis)
William and Mary, College of
Wisconsin, University of (Madison)
Yale University

December 24, 1998

To: See Distribution List

Enclosed is the Final Technical Report for the USRA/High Energy Astrophysics Program under Contract NAS 5 – 32490 for the period of April 1, 1998 through September 30, 1998. Please accept my sincere apologies for the delay in sending it to you.

Sincerely,

David V. Holdridge
Project Manager, HEAP

TABLE OF CONTENTS

Task 93-01-00 – HEASARC	
Corcoran, Michael	03
Drake, Stephen	05
McGlynn, Thomas A.....	08
Task 93-02-00 – ROSAT-GOF	
Snowden, Stephen	9
Task 93-03-00 – ASCA-GOF	
Gotthelf, Eric	11
Mukai, Koji	13
Task 93-04-00 – XTE-GOF	
Boyd, Padi	16
Cannizzo, John	18
Lochner, James	20
Smale, Alan	21
TASK 93-09-00 – RMT/BATSE	
Barthelmy, Scott.....	24
TASK 93-10-00 – TGRS/WIND	
Palmer, David.....	26
Task 93-11-00 – HE Cosmic Rays	
Mitchell, John.....	28
Task 93-12-00 – EGRET	
Sreekumar, P.	51
Task 93-13-00 – Theory	
Mandzhavidze, Natalie.....	53
Task 93-14-00 – Mirror Development	
Chan, Kai-wing	54
Soong, Yang	58
Task 93-20-00 – CGROSSC	
Barrett, Paul.....	60

Bridgman, W. Tom.....	62
Shrader, Chris.....	64
Watanabe, Ken	66
Task 94-07-00 – XTE-SOF	
Corbet, Robin	68
Takeshima, Toshiaki	70
Task 96-02-00 – GLAST/GTOTE	
Moiseev, Alexander.....	74
Task 97-02-00 – ASTRO-E	
Ebisawa, Ken.....	75
Task 97-03-00 – Detector Technology	
Krizmanic, John	76
Task 98-01-00 – Space Physics	
Baring, Matthew.....	78

University Space Research Association

High Energy Astrophysics Program

Technical Report April 1, 1998 to September 30, 1998

Task 5030/93-01-00 – HEASARC

Dr. Michael F. Corcoran

Science Tasks:

During this interval I served on the organizing committee of the "Eta Car at the Millenium" workshop which took place in Jul, and presented 2 papers (one on X-ray imaging of Eta Car, and one on the X-ray spectral variations). I published 2 papers (ApJS, 118, 217 and MNRAS 299, 5P). I continue to supervise UMinn grad student Kazunori Ishibashi who's involved in the analysis of our RXTE monitoring of Eta Car. I was also PI on 2 successful AXAF AO1 proposals to observe the high-resolution spectrum of Eta Car and to image the "starburst" region NGC 3603. In addition I attended the 192 AAS meeting in San Diego in June and presented a paper on our recent ASCA spectra of Eta Car.

Programmatic Tasks:

ROSAT - On Jun 5 we released the first version of the ROSAT Results Archive for the HRI. This catalog contains arcsecond positions and count rates of detected sources from more than 2,000 public ROSAT HRI observations. The catalog consists of all primary source parameters from the automated detection algorithm employed by the Standard Analysis Software System (SASS). In addition each observation has been quality checked, both by automatic algorithms and by detailed visual inspection. The results of this quality checking are contained as a set of logical-value flags for each principal source parameter. If a source parameter is suspect, the associated flag is set to "TRUE"; parameters with no obvious problems maintain the default, "FALSE", value. In addition to the catalog, data products for each screened observation are also available. These data products include the screened source lists, FITS images, and ASCII files containing information about obvious real sources not detected by the SASS detection algorithms. I have also set up and maintain the ROSHRI web site at GSFC. During this interval we ingested into the ROSAT Data Archive 10 new releases of ROSAT data. I also became involved with the task of understanding and solving problems caused by the inadvertent processing of ROSAT data with incorrect boresight parameter information. I also put together the 8th volume of ROSAT images on CDROM; these CDs were distributed at the 192nd AAS meeting. As part of my GOF duties I answered numerous e-mail requests for information during this interval and provided on-site help to Lori Lanier.

CALDB:

During this time I answered numerous questions from users via e-mail. I continued the development and refinement of the CALDB web site and document revisions. I helped verify the y2k compliance of the CALDB software.

General HEASARC activities:

I attended meetings on the y2k compliance of HEASARC software and web sites. I also helped review updates of W3Browse and ASTROBrowse, and did general troubleshooting.

Task 5030/93-01-00 – HEASARC

Stephen A. Drake

Work accomplished and in progress

(i) Science Related

- Guest Investigator Proposal Status

Of the two AXAF Guest Observer (GO) proposals for AO-1 that I submitted in January 1998, one proposal was approved to observe the active binary stars Algol and UX Ari with the ACIS-HETG combination of instruments for a total of 100,000 seconds of exposure time, and a \$66,000 budget. The AXAF proposal that I was also a Co-I on led by Manuel Guedel (Paul Scherrer Institute, Switzerland) to observe the star YY Men was turned down. In another AO (Research Opportunities in Space Science, Astrophysics Data Program), I was a Co-I on a successful proposal led by Ted Simon (University of Hawaii) that will analyze data from our ASCA AO-3 program on the active binary 29 Dra, as well as data on a dozen or so similar stars in the ASCA archive. Finally, the RXTE Cycle 4 proposal of Mike Corcoran's (USRA) to continue the monitoring of Eta Carinae that I was a Co-I on was accepted.

- Scientific Publications and Science Citation Rate

My projected tally for 1998 is 11 papers, of which 7 papers are or will be in refereed journals, 1 is a review article, and 3 are in conference publications or newsletters. Of these 11 papers, I was first author of 3, and 2nd author of another 2 papers. In addition, I have 1 paper in press to be published in 1999, and 4 other papers that are expected to be submitted in the near future. (See the attached bibliographies for 1998 and 1999).

The citation rate for my (first-author) papers in 1997 (excluding self-citations) was 57 references, similar to the average number (49) of references per annum that such papers have received in the previous six years. Since I have been the first author of about half of the papers in which I have been involved, I estimate that the total citation rate for all my papers is about 100 references per annum. In terms of citations per paper, the average number of citations for all 53 of my first-author papers is 11.5 per paper, while for the 21 first-author papers in refereed publications it is 24.2 per paper. I have written 10 papers which have received 20 or more citations, my thesis publication in 1980 having received the most (113) of any of my papers.

- Conferences, Meetings, and Workshops

I attended a meeting on 'Solar and Stellar Activity: Similarities and Differences' held in Armagh, N. Ireland from September 2 to 4 1998, and presented a poster paper on simulated AXAF grating spectra of active stars.

- Refereeing and Proposal Reviewing Duties

I participated in the AXAF GO AO-1 Reviews that were held in the Boston area in early April, 1998. I submitted a second referee's report for a paper that had been submitted to Astronomy and Astrophysics and which I had rejected on the initial submission.

- Other Science Activities

I was involved (at a minor level as a Co-I) in the preparation of the proposal for a joint UX and X-ray monitoring mission called 'Kronos' that was submitted in response to the last Mid-Ex AO. Brad Peterson (Ohio State U.) is the PI, and the deputy PI is Ron Polidan (GSFC).

(ii) Programmatic

I continued to monitor the WWW, and anonymous ftp services provided by the HEASARC to the scientific community. We are presently transferring data via these utilities at a total rate in excess of 100 Gigabytes per month, which is about a factor of 2 higher than it was 6 months ago. Since the beginning of 1993 our data transfer rate has increased by 2 orders of magnitude!

The HEASARC data archive has reached a size of about 1200 Gigabytes, which is about 500 Gigabytes more than a year ago.

I acted as the scientific editor for the 1998 issue of the HEASARC journal *Legacy*, with Natalie Barnes acting as the Technical Editor. The issue ended up with more than 20 articles and a total of 88 pages, and, apart from one article which had some typographical errors inadvertently introduced during the editing process, appeared to have been a success.

In the six month period covered by this report we created and/or updated (or fixed bugs in) 22 databases for the HEASARC's on-line services.

I continued to work with Phil Newman (GSFC) and Tom McGlynn (USRA) on maintaining the new HEASARC EUVE archive, interacting with the Center for Extreme-Ultraviolet Astrophysics, NSSDC and STScI. Inter alia, with the assistance of Karen Smale (RSTX), I created a set of HEASARC EUVE Web pages.

NON-LOCAL TRAVEL

1. To Waltham, MA to attend AXAF AO-1 GO Proposal Reviews from April 5 - 7, 1998.

2. To Armagh, NI to attend a meeting on 'Solar and Stellar Activity: Similarities and Differences' from September 2 - 4 1998

WORK PLANNED FOR NEXT SIX MONTHS

I will continue my research into the coronae of stars using hard X-ray, soft X-ray, extreme-ultraviolet, and radio observations as probes of their physical environments.

I will continue overseeing the anonymous ftp account on HEASARC's LEGACY computer, as well as the request@legacy user hotline. I will continue monitoring our creation of BROWSE and W3BROWSE databases and catalogs.

I will keep those WWW pages for which I have responsibility up to date.

[Attachments will be sent together with paper copy of this report].

Task 5030/93-01-00 – HEASARC

Tom McGlynn:

Technical Report:

Responsibilities:

Worked as HEASARC Chief Archive Scientist to maintain and enhance NASA's high energy archives and the software systems used to access them.

Accomplishments:

Led efforts to build HEASARC Web services.

Made substantial enhancements to the HEASARC's Web browser software, W3Browse, including cross-correlations among data types and an index of all catalog resources.

Completed effort to transition HEASARC from Ingres to Sybase database system.

Led HEASARC efforts in Y2K testing including time shift tests of all HEASARC developed software.

Led effort to develop Astrobrowse, including coordination with other astronomical institutions around the world (CDS, IPAC, ADF/ADC, STScI, NCSA). Astrobrowse is now a mature system with nearly 2,000 distinct astronomical resources. Its GLU database is maintained in cooperation with many other astronomical institutions.

Wrote most of large scale AISR proposal to continue integration of NASA's space science data systems.

Wrote and submitted renewal proposal for SkyView virtual telescope to NASA AISR.

Worked with USRA senior staff in proposal for Code 630 support.

Developed new energy converter tool for HEASARC Web pages.

Coordinated activities with Raytheon (nee STX) staff.

Continued development and maintenance of SkyView virtual telescope including major UV and X-ray surveys.

Developed IDL tools for writing generic FITS files.

Developed SkyMorph web site in collaboration with JPL colleagues.

Supported incorporation of CGRO data within the HEASARC.

Managed incorporation of EUVE data within the HEASARC: the HEASARC will be the sole active archive for EUVE data.

Provided support for cleaning of WGACAT database.

Task 93-02-00 – ROSAT-GOF

Dr. Steven L. Snowden

Programmatic Work:

Currently my duties are still split between the ROSAT and XMM GOFs. However, the transition between the two is nearly complete with only a few minor ROSAT duties left. I will continue to be available to the ROSAT project when appropriate.

XMM GOF

My XMM GOF duties continue to include learning about the observatory in preparation for the release of the first AO (16 November 1998), creating and maintaining GOF web pages, organizing an XMM booth for AAS meetings, and familiarizing myself with the XMM documentation and software.

In a major effort, I've written an XMM EPIC data simulator to aid in proposal writing. I've also written software to convert the project simulator (SciSim) output to a more usable format.

ROSAT GOF

Extended Source Analysis Software:

I've continued the task of maintaining and answering GO questions about this software package. Kip Kuntz and I completed our preparation of a final version of the ESAS package. The software has been made more intelligent to simplify its use and to make pipelining of tasks considerably more convenient. We have also produced a major revision of the documentation.

TREND Data Analysis:

The TREND data processing continues in production mode with 2592 days completed. The reprocessing of GO data is complete so only new data are being reduced.

PSPC Spectral Calibration:

Still no real progress here. MPE will not release the new XRT mirror effective areas so improvement of the calibration must be done their. Jane Turner and I produced a memo discussing the calibration of the residual spatial gain variation but are waiting on MPE (at their explicit request) for publication.

HRI Particle Background Calibration:

The HRI particle background paper appeared in press in ApJ Sup.

Scientific Work:

I'm still working on a catalog of shadows in the soft X-ray diffuse background.

Public Outreach:

I am a member of the HEASARC Public Outreach group and have been participating in the creation of the WWW education pages.

My mentoring of University of Maryland graduate student Kip Kuntz is in its last half a year.

Travel:

Trips for XMM Programmatic work:

April - Leicester University: discuss cooperation in the project
May - MPE: Science Survey Consortium meeting, gave science talk
June - San Diego: Ran XMM booth at the AAS meeting

Trip for science purposes:

July - Victoria, IAU Colloquium: Presented invited talk on the Magellanic Clouds

Plans for the Next Half Year:

XMM

I'll continue preparing for the release of XMM AO-1

Trips for XMM Programmatic work:

October - ESTEC: XMM Science Working Group and First XMM Workshop, presented poster on NASA/GSFC XMM GOF
October - Santander: Science Survey Consortium meeting
December - ESTEC: XMM Science Working Group, Leicester: discussions with SSC personnel
January - San Antonio: Run XMM booth at the AAS meeting

ROSAT

Trend processing will continue but with a smaller time commitment.

Science

Besides the mentoring of Kip Kuntz, I expect that the time pressures of the XMM AO will not allow for much in the way of science for the next half a year.

Task 93-03-00 – ASCA-GOF

Gotthelf, Eric

Research:

Searching through ASCA data for new examples of "Anomalous X-ray Pulsars" (Collaboration with Dr. G. Vasisht, California Institute of Technology).

Analyze new observations of Kes 73, the recently discovered 12-sec Anomalous X-ray Pulsar (Collaboration with Dr. G. Vasisht, California Institute of Technology and Dotani, T. of ISAS, Japan).

Analyze new observations of the supernova remnant RCW 103, in collaboration with Drs. R. Petre of GSFC, Dr. G. Vasisht of Caltech, & Dotani, T. and Torii, K. of ISAS, Japan

Finishing up a paper on the Supernova remnant Cas-A, in collaboration with Drs. Koralesky, B. Keohane of the Univ. of Minnesota.

Project Work:

Managed the ASCA archive.

Wrote software to check and maintain the ASCA archives

Re-calibrated and improved the ASCA pointing accuracy.

Maintained and updated ASCA calibration software.

Performed various ASCA GOF duties.

Participated in the AXAF review as a scientific panel member.

Refereed Publications:

Koralesky, B., Rudnick, L., Gotthelf, E. V., & Keohane, J. W. 1998 "The X-ray Expansion of the Supernova Remnant Cassiopeia A," *ApJ*, 505, L27.

Singh, K. P., Drake, S. A., Gotthelf, E. V., & White, N. E. 1999 "X-Ray Spectroscopy of Rapidly Rotating, Late-Type Dwarf Stars," *ApJ*, 512, 100.

Keohane, J. W., Gotthelf, E. V., & Petre, R. 1998 "Evidence for Proportionate Partition Between the Magnetic Field and Hot Gas in Turbulent Cassiopeia A," *ApJ*, 503, L175.

Gotthelf, E. V. & Vasisht, G. 1998 "Discovery of a 7 Second Anomalous X-ray Pulsar in the Distant Milky Way," *New Astronomy*, 3, 293

Marshall, F. E., Gotthelf, E. V., Zhang, W., Middleditch, J. & Wang, Q. D, 1998 "Discovery of an Ultra-fast X-ray Pulsar in the Supernova Remnant N157B," *ApJ*, 499, L179.

Torii, K, Kinugsa, K., Toneri, T., Asanuma, T., Tsunemi, H., Dotani, T., Mitsuda, K., Gotthelf E. V. & Petre, R. 1998 "Discovery of a 69 millisecond X-ray Pulsar: A compact source in the Vicinity of the Supernova Remnant RCW 103," *ApJ*, 494, L207.

Gotthelf E. V. & Kaspi, W. M. 1998 "X-ray Emission from the Radio Pulsar PSR J1105-6107," *ApJ*, 497, L29.

Wang, D. Q. & Gotthelf, E. V. 1998 "ROSAT AND ASCA Observations of the Crab-like Supernova Remnant N 157B in the Large Magellanic Cloud," *ApJ*, 494, 623.

Conference Proceedings:

Gotthelf, E. V. 1998 "Radio-quiet X-ray pulsars in Supernova Remnants and the 'Missing' Pulsar Problem" in 'Workshop on the relationship between Neutron Stars and Supernova Remnants', *Memorie della Societa' Astronomica Italiana*, in press.

Gotthelf, E. V., Zhang, W, Marshall, F. E., Middleditch, J., & Wang, Q. D. 1998 "A 16 Millisecond X-Ray Pulsar in the Crab-Like SNR N157B: Fast Times at 30 Doradus," in 'Workshop on the relationship between Neutron Stars and Supernova Remnants', *Memorie della Societa' Astronomica Italiana*, in press.

Petre, R. & Gotthelf, E. V. 1998 "X-ray variability of the central source on RCW 103," in 'Workshop on the relationship between Neutron Stars and Supernova Remnants', *Memorie della Societa' Astronomica Italiana*, in press,

Steinberger, J. K., Kaspi, V. M., Gotthelf, E. V. 1998 "RXTE Observations of PSR J1105-6107," in 'Workshop on the relationship between Neutron Stars and Supernova Remnants', *Memorie della Societa' Astronomica Italiana*, in press.

Kaspi, V. M., Lackey, J. R., Pivovarov, M. J., Mattox, J. R., Gotthelf, E. V., Manchester, R. N., Bailes, M., & Pace, R. 1998 "Gamma-ray observations of the young radio pulsar PSRs B1046-58 and J1105-6107," in 'Workshop on the relationship between Neutron Stars and Supernova Remnants', *Memorie delta Societa' Astronomica Italiana*, in press.

Task 93-03-00 – ASCA-GOF

Koji Mukai

Technical Report

1. ASCA Matters:

In addition to the routine GO support (mostly answering questions via e-mail), my ASCA works over the previous 6 months included:

(1) Organizing the ASCA AO-7 review. We have secured 24, high-quality reviewers and assigned proposals (102 in total) into 4 panels, and assigned primary & secondary reviewers to each proposal within ~4 weeks of the proposal deadline (Sep 1).

(2) Updated the SIS analysis chapter of the ASCA data reduction guide, in response to our evolving understanding of the instrument and the recent updates in the analysis software.

2. ASTRO-E Matters

We had regular ASTRO-E GOF meetings; during this period, most of the works were being done by the instrument teams, ADF, and by Ken Ebisawa.

3. Research

I was the main organizer for the Annapolis Workshop on Magnetic Cataclysmic Variables, July 13-17. It was a success, in my somewhat biased opinion, with about 80 participants from all over the world.

One of my 2 AXAF proposals (submitted in January) was accepted; I was a co-I of two FUSE proposals (one was accepted); I submitted 2 XTE proposals, for coordinated observations with AXAF and FUSE respectively (both were accepted at least in part); and I have submitted 2 ASCA proposals.

I presented the analysis of a serendipitous ASCA observation of the X-ray binary in a globular cluster, NGC 6652, at the San Diego AAS meeting. I am working on a journal paper.

The following papers have appeared in refereed journals during this period:

“Rapid oscillations in cataclysmic variables XIII. WZ Sagittae revisited,” Patterson, J., Richman, H., Kemp, J., Mukai, K. 1998, PASP 110, 403-414.

“BeppoSAX observations of the long period polar system V1305 Ori,” de Martino, D., Barcaroli, R., Matt, G., Mouchet, M., Belloni, T., Beuermann, K., Chiappetti, L., Done, C., Gaensicke, B.T., LaFranca, F., Mukai, K. 1998, A&A 332, 904-908.

“An alternative model of the magnetic cataclysmic variable V1432 Aquilae (=RX J1940.1-1025),” Mukai, K. 1998, ApJ 498, 394-398.

“The changing X-ray light curves of the intermediate polar FO Aquarii,” Beardmore, A.P., Mukai, K., Norton, A.J., Osborne, J.P.

“Iron K-alpha line widths in magnetic cataclysmic variables,” Hellier, C., Mukai, K., Osborne, J.P. 1998, MNRAS 297, 526-530.

“The X-ray emission of the polar BL Hydri,” Matt, G., Barcaroli, R., Belloni, T., Beuermann, K., de Martino, D., Done, C., Gaensicke, B.T., Guainazzi, M., Mouchet, M., Mukai, K. A&A 334, 857-862.

Asai, K., Dotani, T., Nagase, F., Ebisawa, K., Mukai, K., Smale, A.P., Kotani, T. 1998, "ASCA observation of the supersoft X-ray source CAL 87", ApJLett, 503, L143.

4. Community service

I was a reviewer in the AXAF AO-1 proposal review.

I have updated my count rate estimate software, PIMMS, for XMM, ASTRO-E XRS, and for Constellation-X.

5. Public Education and Outreach.

I have taken over as the coordinator of the Ask a NASA Scientist service in late May. In response to the greatly increased number of questions, I supervised the introduction of several new features to keep the number of questions to a manageable level. I also continue to serve as one of the hotseaters (7 times during this period, answering ~30 questions each).

I have started the work towards developing an ASTRO-E Learning Center.

5. Projection of future activities:

Major events during the next 6 month periods include:

- * A trip to Japan in October to participate in the first integration test of ASTRO-E and to discuss software issues with instrument team members.

- * ASCA AO-7 proposal review in early November, with preparations through October.

- * A trip to Japan in December for an ASTRO-E Science Working Group meeting and ASCA AO-7 merging meeting.

- * AAS meeting in January in Austin, TX, where I will present a poster and participate in the ASTRO-E booth and special session.

* Another trip to Japan in March for a conference and an ASTRO-E SWG meeting.

Nevertheless, I hope to submit 2-3 papers for publication during this period!

Task 93-04-00 – XTE-GOF

Patricia T. Boyd

Technical Report

During this period, I was on maternity leave from March 1 through May 21, 1998.

RXTE support:

-Web duties: I am responsible for the RXTE electronic interface with the scientific community through the development and maintenance of many web pages. During this period, I designed the Greatest Hits of RXTE pages, which contain scientific discoveries based on RXTE observations. Currently there are 10 articles on this set of pages. I also maintained the papers pages, which contain links to over 150 refereed scientific publications based on RXTE data.

-Software duties: I designed and oversaw the development of a collection of software tools crafted to search for nonperiodic time evolution in RXTE data. These tools will be part of the next FTOOLS release, and are currently in the last stages of testing. The tools generate a dynamical energy spectrum for studying the time evolution of spectral features, a dynamical power spectrum, for studying the time evolution of frequencies present in a time series, and a close return map, for searching for segments of near periodicity in a complicated time evolution.

-General support duties: About once per month, I man the RXTE hotseat, an email question and answer service for helping GOs analyze their data. As GOs visit the facility, I lend scientific support on a rotating basis with the other three duty scientists.

Scientific meetings:

-I attended the June 1998 AAS meeting in San Diego to present an invited talk in the special session on pulsars in the ultraviolet.

-I attended the April 1998 APS meeting in Columbus, OH to participate in the Division of Astrophysics annual meeting as Secretary-Treasurer.

Proposals:

-I was awarded RXTE time to study Vela X-1 as part of a multiwavelength campaign to use reprocessed pulses to determine the mass of the system.

-I am a co-I on the companion HST proposal, currently under review.

Outreach:

-AstroCappella: initiator and co-I of this IDEA grant supported educational tool. Currently we've distributed over 3000 copies of the CD and companion lesson plan booklet to educators across the country.

We've attended many educational meetings where we've presented our own workshop or been part of the LHEA outreach workshop.

-How do Astronomers Weigh the Stars: This IDEA grant funded project is near completion, with the assistance of a NASA teacher intern (Tracey McCormick) and student researcher Terra D. Colvin. We have a set of activities based on real NASA astrophysics data from the binary system Vela X-1, and will be putting some of this up on the WWWeb in the near future. It will also be included in the Imagine the Universe web site.

-LHEA outreach: I've remained active in the outreach group of our lab, coordinating the group meetings and overseeing the travel to various meetings for the upcoming year. I represented our lab at the NEWMAST exhibits on July 10th at GSFC, and for Community Day on September 25.

-senior project student: I oversaw the senior project of Potomoc HS student Kip Lewis in early June, collaborating on a project involving the mathematical relationship between harmonic musical tones on a piano (well-tempered tuning) versus just intonation. Kip worked at GSFC for two weeks on the project.

Task 93-04-00 – XTE-GOF

John Cannizzo

Report for 1 Apr - 30 Sep 1998:

Talks:

Dept. of Astronomy, Columbia University, NY, May 15, 1998
"Constraints on the Physics of Accretion Disks from SS Cygni"

Refereeing:

Astrophysical Journal: 2
Monthly Notices of the Royal Astronomical Society 3

Conference:

AAS Meeting in San Diego, CA - Jun 1998

Committees:

ADP/LTSA Panel in Washington, DC - Jul 1998
RXTE Panel in Alexandria, VA - Sep 1998

Papers:

"Accretion Disks in Transient Systems," Cannizzo, J. K. 1998, in ASP Conf. Ser 137, Proceedings of the 13th North American Workshop on Cataclysmic Variables and Related Objects, 308-322

"Low States in Cataclysmic Variables," King, A. R., & Cannizzo, J. K. 1998, The Astrophysical Journal, 1998, May 20, vol. 499, pp. 348-354.

"A Study of the Outbursts in SS Cygni," Cannizzo, J. K., & Mattei, J. A. 1998, The Astrophysical Journal, 1998, Sep 20, vol. 505, pp. 344-351.

Functional:

The service work consists of assisting RXTE GOs in reducing their data. My main work consists of running extensive test suites of the "ftools" which are utilized to analyze RXTE data. The 4 duty scientists also rotate weekly shifts in which we answer detailed technical questions to the e-mail "xtehelp". I am also on hotseat rotation for "Ask a NASA Scientist".

.....
Invitation for to serve on SOC board for conference:

From: "Shin Mineshige" <minesige@kustastro.kyoto-u.ac.jp>

Date: Fri, 20 Mar 1998 15:19:55 +0900

To: cannizzo@stars.gsfc.nasa.gov

Subject: disk-instability workshop at Kyoto

Dear John,

This is to ask a favor of you.

As you know, it has already passed 24 years since Prof. Yoji Osaki proposed the disk-instability model for dwarf-nova outbursts in 1974. To celebrate the 25th anniversary of the disk-instability model, we are planning to have a small workshop. In this workshop, we first review the progress in the research owing to the disk-instability model, both for dwarf novae and X-ray novae (soft X-ray transients), and then discuss the future direction of the accretion-disk research, with emphasis on the various kinds of disk instabilities. In order to have intense discussion (and also due to financial reasons), the topics and the number of participants are strictly limited.

Although the details have not been decided yet, I wish if you could be a member of SOC and attend the workshop. We will be able to support your travel and stay at Kyoto during the workshop.

If you would agree with this and would be able to attend, please reply to me soon.

Best regards,

Shin

invitation to participate in ITP Santa Barbara school:

.....
*From: SMTP%"doug@itp.ucsb.edu"
Date: Fri, 23 Jan 1998 11:06:35 -0800 (PST)
From: Doug Eardley <doug@itp.ucsb.edu>
X-Sender: doug@chopin
To: cannizzo@lheavx.gsfc.nasa.gov
Subject: Black Hole Astrophysics at ITP*

Hi John Cannizzo,

I'm writing to invite you to participate in a program at the Institute for Theoretical Physics, called "Black Hole Astrophysics" to be held in winter/spring 1999. The write-up below lays out the scientific purposes of the program, which I think you will find interesting. The other coordinators and I hope you will be interested in participating for the whole program, or a substantial part of it. The ITP emphasizes long term stays (>3 mo) during programs, and can give partial salary support only for such stays. Travel and displacement support is also available.

I don't believe you have visited the ITP before. I'll be happy to provide further info, or have a look at "www.itp.ucsb.edu". Since your work depends on computers, I should mention in particular that we have good computing facilities.

We would like informally to get a quick reading on your likelihood for such a long term stay. A formal invitation from ITP will then follow. I very much hope to hear from you.

*Best regards, --Doug.
doug@itp.ucsb.edu
(for all 3 coordinators)*

BLACK HOLE ASTROPHYSICS

Task 93-04-00 – XTE-GOF

James Lochner

During the past half year, while continuing to support day-to-day activities in the RXTE Guest Observer Facility, I have carried out continuing RXTE observations of transient pulsars in the Small Magellanic Cloud, and have continued to pursue education and outreach activities.

With Maggie Masetti (STX), I continued development on the RXTE Learning Center. We added three new articles to the web site's "RXTE Discoveries" section. Under my direction, Ms. Masetti also wrote and designed an activity book to accompany the RXTE paper model she designed last fall. The text for the booklet was also reviewed by other scientists in the Lab and by teachers. The completed booklet was submitted to GSFC's Graphics and Printing Office near the end of September. The booklet will be distributed to teachers at upcoming teacher conferences.

In the late spring we also finished our preparations on the education interface to the RXTE ASM data and made it public. During the summer, Ms. Rachelle Andrews (Parkdale High School) worked with us as a GSFC Summer Teacher Intern to develop lesson plans and activities which utilized the data. She developed a plan for a set of lesson plans and completed the first of them, a graphing activity, by the end of the summer. Staying on under contract, she started the second of them, an activity using trig functions, in September.

Dr. Laura Whitlock (USRA), Ms. Bruce Hemp (Stewart Middle School, Ft. Defiance, VA) and I implemented our "Live from RXTE" project, an accepted AO-3 RXTE proposal. Part of this project involved engaging middle and high school students in predicting the time of an eclipse from the X-ray binary system X1700-377. Students used data from the XTE All Sky Monitor to estimate the system's orbital period and the times of previous eclipses. The students would then watch the RXTE observation using the RXTE Remote Observing interface on the web. Dr. Whitlock and I met with Ms. Hemp and two other teachers participating in the project in early Sept for background and training. Our visit and the project was featured in the local newspapers. Nine teachers carried out the project with their students in Sept. A hoped-for observation on Oct 1 was bumped because of a Target of Opportunity. But we hope for an observation in late Oct, when we will visit the teachers and their students.

My activities for the RXTE GOF continue to be wide-ranging. I continue to update and maintain the archive of data products from the All Sky Monitor, act as an interface for the teams to the HEASARC's calibration database, and provide assistance to users via email and their visits to us. In September I supported the RXTE Cycle 4 Proposal Review by providing scientific technical expertise for one of the four review panels. I also handled the post-review follow-up as needed for accepted proposals on that panel.

Task 93-04-00 – XTE-GOF

Smale, Alan

Summary:

Over the last six months, I continued to direct the activities of the RXTE GOF, from proposal management and Guest Observer support, through data analysis. I also helped to write the RXTE Senior Review proposal, and a MIDEX proposal. I have continued my scientific involvement with RXTE data analysis, published several papers, and performed many outreach-related activities, many connected with the successful AstroCappella project.

(1) PROGRAMMATIC DUTIES:

During this time period, a number of important RXTE programmatic goals were achieved.

- * We released the Cycle 4 Announcement on April 15th, with proposals due July 15th, and the Peer Review in September. I prepared the Announcement, supervised the proposal submission process, and organized the entire Peer Review (selecting reviewers, dividing proposals and reviewers into panels, writing the Instructions for Reviewers, overseeing the Review, etc). All deadlines were met, and the Review process was terminated successfully with the release of the Review results and the letters to the proposal PIs, which were sent out less than two weeks after the Review finished (ahead of schedule).
- * Performed extensive testing of RXTE software. Helped release an RXTE-related FTOOLS patch in June, and supported the RXTE side of a full-up general FTOOLS release planned for later in the year. Helped develop and test a new version of the XSELECT program, which can now analyze RXTE PCA Standard Mode 2 data, and prepared it for release. Wrote various related user recipes for the RXTE GOF online documentation.
- * Took my turn on the RXTE Email help desk one week in four, answering user questions. Also assisted visiting GOs as a Duty Scientist. Performed numerous miscellaneous duties to help Guest Observers with their analysis, and their understanding of the RXTE mission.
- * The RXTE PCA team made progress in improving the PCA background model during this interval, helped by substantial effort from the GOF, who ran scripts for them and did a great deal of testing. Coordinated this effort and did quite a lot of testing myself.
- * Wrote sections for the Senior Review proposal text for RXTE. In the Senior Review, RXTE came top of the operating missions, ahead of ASCA, ROSAT and GRO, and beaten only by WIRE, which has not yet been launched.

And in addition:

- * Contributed substantially to the data flow and data analysis sections of a GSFC-led MDEX proposal for a satellite to be known as SWIFT, a gamma-ray burst chaser.

(2) SCIENTIFIC RESEARCH:

- * Performed an observing run at CTIO in June, using the 1.5m + IR instrument, in support of my multiwavelength project to study GX13+1, a bright Galactic bulge X-ray source. Began the detailed analysis of the RXTE data from GX13+1.
- * Performed high-time-resolution analysis of a wide variety of LMXBs, searching for kilohertz quasi-periodic oscillations and other timing signatures.
- * Wrote and submitted a paper on simultaneous RXTE/CTIO observations of the (usually) dipping source 4U1254-690, entitled "A Cessation of X-ray Dipping Activity in X1254-690". These data were obtained last year.
- * Performed an RXTE target-of-opportunity observation of the cataclysmic variable V592 Her in outburst, and analyzed the data (unfortunately, not particularly scientifically interesting).
- * Wrote a successful RXTE Cycle 4 proposal to study LMC X-3, and was a co-I (and helped to write and make successful) 5 other Cycle 4 proposals.
- * Collaborated on papers studying: the ASCA spectrum of the dipping source X1916-053 (Ko et al); the ROSAT data from the same source (Morley et al); ASCA and HST observations of Cyg X-2 (Vrtilek et al); and the globular cluster X-ray source X1832-230 (Mukai (USRA) et al).

(3) EDUCATIONAL OUTREACH:

- * I continued to support the AstroCappella project, with my colleague and friend Padi Boyd (USRA) and the members of the singing group The Chromatics. During this interval we pressed a further 3000 copies of our educational music CD and booklet, and received a lot of favorable feedback on the project from the teacher community.
- * Attended the National Science Teachers Association meeting in Las Vegas in April; sang, did workshops, staffed education booths, met teachers, gave away goodies.
- * Helped write and issue a press release on AstroCappella at the San Diego AAS meeting in June.
- * Appeared on CNN, singing AstroCappella songs at Space Day on the Mall in Washington DC with the Chromatics in May. Also performed

in a planetarium show at the local Owens Science Center Open Day in May.

* Wrote an article about AstroCappella for the 4-H newsletter, "Skylights", which appeared in the September issue.

TASK 93-09-00 – RMT/BATSE

Barthelmy, Scott

CZT Detector Development & the SWIFT MidEx Proposal:

We are collaborating with 2 foreign institutions and 2 US university groups. I am responsible the mechanical & packaging design and vibration & thermal testing of the CZT detectors and the front-end electronics. I designed, built and tested the first two flight-like modules and electrical & x-ray testing has begun. The MidEx proposal was submitted Aug 21, however, we are continuing to work full-speed ahead as if we are going to be one of the four winners to do a Phase A study. My work now consists of overseeing the design of the flight controller for the (above) flight-like detector modules. I supervise 2 e-tech's and 1.2 e eng's on this effort. I spend about 50% of my time on this effort.

InFOCuS project activities:

I continue as instrument scientist for InFOCuS. I finished the mechanical design of the CsI Shield and the procurement to Bicron (\$55K) is in place and they are beginning fabrication. Work is progressing on the shield electronics (PMT selection, base design, and linear electronics), and on the micro-processor development, the flight software, and the housekeeping system. I am working hard to make the Winter deadline for a test flight of the CZT detector and Shield subsystems (on an unpointed mini-gondola). The total list of people I oversee is 1.2 e-techs, 1 mech eng, 1.5 mech techs, and 1 programmer. This is about 50% of my time.

GCN (BACODINE) project activities:

The GCN (GRB Coordinates Network) project continues grow. The 13 optical and radio counterparts to recent GRBs in the last 18 months has brought the state of GRB follow-up research into high gear. The current number of GCN sites is 108 and growing.

GCN continues collects and distributes location information from other spacecraft. Positions from the BeppoSAX-WFC & -NFI instruments were added to the list. The GCN web site now has pages/tables which are updated in real-time with all this information -- it serves as another distribution method and as an archive.

The GCN Circulars (added last semester) continue to be very popular with the follow-up community; the list of validated submitters and recipients is currently at 297. These "circulars" are reports submitted by the burst follow-up community (optical, radio, x-ray, etc), and are prose-style (as opposed to the highly formatted notices from the first two parts of the GCN system) from

observers about the observations they have made (magnitudes, fluxes, spectra, refined locations, upper limits, etc). I wrote a mail server which validates the incoming reports and distributes them (58 so far) to a list of interested people (>250 so far).

I am working to expand the GCN system to cover other astrophysical targets which are transient in nature (x-ray transients, novae, supernovae, CV's, etc) -- anything which is transient & short-lived for which real-time follow-up observers are critical to the science: "real-time science". GCN occupies about 25% of my time.

LOTIS/Super-LOTIS activities:

I have formed a collaboration with the LOTIS team at LLNL and Clemson U to install the Super-LOTIS instrument (the 3rd generation GRB follow-up instrument) on Kitt Peak (where the my old RMT instrument is currently resting quietly). A recent trip to Kitt Peak to meet the principle players has solidified this effort. First light will be late-Fall or Winter. This is about 10% of my time.

GTOTE project activities:

This project has been in a period of zero activity. Although it may end up as part of a Super-LOTIS system described above.

GRB POLARIMETER project activities:

After completing some lab measurements to correlate with the GEANT modeling work (Ben Mazin), the project was put on hold (about 1% of my time) while we look for a "ride" into space.

GRIS project activities:

Nothing to report. GRIS is in stasis awaiting a nearby supernova.

TASK 93-10-00 – TGRS/WIND

David Palmer

For the past 6 months I have been working on:

- 1) development of our next Medium Explorer (MIDEX) proposal,
- 2) characterizing and responding to gradual radiation damage in the Transient Gamma Ray Spectrometer (TGRS),
- 3) Gamma-Ray Burst timing with the NEAR spacecraft,
- 4) Analysis of Soft Gamma Repeater data, and
- 5) Educational activities.

1) Development of Swift, our next MIDEX proposal: Our group has proposed a GRB instrument which consists of a coded aperture wide-field gamma-ray burst telescope, and additional instruments which will be re-pointed towards a burst when one is detected. This new instrument (called Swift) uses CdZnTe detectors arranged in a mosaic of about 30,000 detectors with 4 mm resolution. (Our previous proposal used a smaller area of CdZnTe detectors with strips applied to give 0.03 mm resolution). This detector array will be combined with a coded aperture mask to produce images with $\sim 1/3$ degree resolution.

I have been working on the design this instrument. A prototype detector module (128 detectors) has been built and checked out, and I constructed a prototype mask and successfully imaged a source with it. With this and other work, we have written up and submitted our proposal. The proposal will be accepted or rejected this December.

2) TGRS, a high-resolution germanium spectrometer for studying GRBs, has been in deteriorating health since November. What had been sharp, narrow lines in the spectra deteriorated to broad double-humped structures. We believe this is due to the radiation damage in the detector.

I have had commands sent to the spacecraft to raise the bias voltage on the detector from an original value of 1950 V stepwise to a current value of 3000 V. Each time the voltage is raised, there is an immediate improvement in the spectrum, but the resolution slowly degrades again as more radiation damage is accumulated.

3) The Near Earth Asteroid Rendezvous (NEAR) mission is a spacecraft which will be going out to visit an asteroid. After launch, it was realized that one of the instruments on the spacecraft could be used as a gamma-ray burst detector. Earlier I helped specify the behavior that the software modifications should have to let the instrument work in this mode.

This instrument had been turned off from January to August. However, it was turned on again in August, just in time to see the

superburst of August 27, 1998 from SGR 1900+14 (see item 4). From timing we have been able to determine the clock accuracy of the NEAR spacecraft, and this will be used to correct further measurements. This will give us good positions for gamma-ray bursts seen by NEAR and at least two other spacecraft.

4) Soft gamma repeaters are highly magnetized neutron stars (a few times 10^{14} Gauss, a thousand times an ordinary neutron star: if Earth's field is represented by a penny, an SGR's field is represented by the US national debt). On Aug 27, for the second time in observational history, one of these sources produced a superburst of $10^{44.5}$ ergs. I have been analyzing the data from this burst, and the results have been submitted to Nature as part.

I have also been looking at archival data from an earlier period of activity from one of these sources. I have found that these bursts act as what is called a 'relaxation system', where an energy reservoir fills from a steady power source and then is dumped suddenly. I will be submitting this result to ApJLett in a few days.

5) On the educational front, I have judged two science fairs and been a hot-seater for the 'Ask-A-NASA-Scientist' service.

Task 93-11-00 – HE Cosmic Rays

Mitchell, John

In September, 1997, I applied for one of the widely advertised and highly competed Term Civil Service positions being offered by GSFC. I was offered this position in Spring, 1998. At the request of Dr. Jonathan Ormes, Laboratory Chief of the Laboratory for High Energy Astrophysics (LHEA), I delayed my transition until after the ISOMAX campaign in Canada in order to save LHEA Civil Service travel funds. I left USRA to begin my Civil Service position on 10/26/98, ending over eight years of service with USRA. Throughout my time with USRA I have found it to be an exemplary organization, highly supportive of my work and that of others at GSFC. I am proud to have worked for it.

My work at GSFC has addressed a broad range of topics in high-energy astrophysics research including: studies of high-energy Galactic cosmic rays as a probe of the origin and history of Galactic antimatter, of stellar nucleosynthesis, and of particle transport processes in the Galaxy; viewing high-energy gamma radiation as a probe of the physics of extreme conditions such as those found in Active Galactic Nuclei; obtaining a new perspective on the Universe through neutrino astronomy at TeV energies; and detection of the highest energy ($>10^{20}$ eV) particles to open a new astronomical window and to probe what may be the most energetic astrophysical processes in the universe. In addition, I have been involved in an active program of high-energy nuclear and particle physics research and in the development of new particle physics detectors.

General Description of GSFC Position Requirements and Responsibilities

I am an integral part of all current and planned HECR projects and am very active in the development of new research efforts. I feel that I have excelled in both of these areas and I play a central role in the majority of HECR projects. After the group head, Dr. Robert Streitmatter, I am the most senior scientific member of the group and function as “second-in-command” in many group activities. In addition to my HECR work, I act as a consultant on particle detection to a number of research groups both within the LHEA and elsewhere in the academic, commercial, and government research communities.

I am an expert in experiment design, particle detectors, detector/trigger electronics, numerical modeling and physical interpretation. I believe that I provide the HECR group and the LHEA a combination of expertise in instrumentation and in the underlying physics which is necessary to achieve some of their most exciting and important goals. My breadth of expertise has allowed the HECR group to undertake a number of projects which would not otherwise have been practical.

I am currently responsible for the HECR instrumental contributions to the balloon-borne ISOMAX and CAPRICE cosmic ray

experiments and the satellite-based PAMELA cosmic ray instrument. I am responsible for the study/development of major components of the OWL orbital ultra-high-energy cosmic ray instrument. I am also the chair of the accelerator test team for the ACCESS ISS instrument calorimeter and am active in efforts to specify the calorimeter technique to be chosen for this mission.

I often play a central role in identifying new areas of research and in developing the approaches to be used. My efforts have been crucial to the considerable success of the HECR group in obtaining funding for its work. In particular, my work has been crucial to the success of the IMAX, ISOMAX, OWL, and PAMELA efforts. My professional reputation, particularly as an instrumentalist, has resulted directly in scientific opportunities for the HECR group, including the group's involvement in the TIGER and PAMELA instruments.

Details of Selected GSFC-Related Research Efforts

ISOMAX: I am the Experiment Manager for the GSFC-led Isotope Magnet Experiment (ISOMAX). ISOMAX was developed by GSFC, Caltech, and the University of Siegen (Germany) to make definitive measurements of the abundance of light isotopes in the cosmic radiation. The highly successful first balloon flight of ISOMAX was carried out from Lynn Lake, Manitoba, Canada on August 4, 1998. In this flight about 16 hours of high-altitude (>118 k feet) data were obtained in addition to ascent data and about 4 hours of data at lower altitude (100 k feet). These data will provide isotopic abundances for cosmic rays with charges up to about 10 and energies to about 1.7 GeV/nucleon.

The ISOMAX measurements of the ratio of radioactive ^{10}Be to stable ^9Be from this and future flights (which will extend the measurements to >3 GeV/nucleon) will provide an essential test of models of cosmic ray transport and storage in the Galaxy. As Experiment Manager, I have the overall task of ISOMAX systems engineering as well as numerous specific responsibilities. I have had the lead role in designing and managing the construction of the instrument/payload, electronics, and superconducting magnet. I also designed and built the state-of-the-art ISOMAX time-of-flight (TOF) detector system.

The work on flight preparation of ISOMAX was demanding and consumed most of my efforts during the past year. I worked extensively on all aspects of the experiment including detectors, magnet, trigger electronics, data acquisition electronics, DC and high voltage power systems, and mechanical systems. This work also required that I coordinate and direct the work of a large GSFC team of scientists (L. Barbier, E. Christian, J. Krizmanic, S. Geier, S. Gupta), engineers (P. Beltran, S. Derdeyn, R. Smith, L. Ryan), and technicians (H. Costlow, S. Holder, L. Lorenz, R. Nace, D. Righter, F. San Sebastian) as well as researchers from Caltech and the University of Siegen.

A major breakthrough in making the ISOMAX flight possible was the completion and delivery of the superconducting magnet. The magnet, for which I am responsible, was designed (based on my strawman) and constructed by Oxford Instruments (OI) in the United Kingdom. This took about three years longer than expected and, in the end, I traveled to Oxford a number of times (the last being in October, 1997) to insure that the engineering and construction of the magnet met our requirements. Even with this work, the magnet failed to meet our full performance specifications. The cryogen hold time is about 25% of the design value, and Oxford was only able to achieve 70% of the design field.

The completed magnet was finally delivered to GSFC in early February, 1998. I immediately began an extensive test and development program with the magnet. In the course of about 1.5 months of work, I was able to fully qualify the magnet for balloon flight including verifying that it met all operational and safety requirements. As a part of my tests, I progressively raised the field of the magnet to investigate the maximum field that could be achieved. I was able to reach a stable field of 80% of the design value without transitioning the magnet to a normal (i.e. non-superconducting) state. I stopped these tests because we ran out of time in the schedule, not because of a performance problem. From the behavior of the magnet, I have an indication that the limiting field is much higher than this, and I have hopes of ultimately achieving close to the full design field. I believe I was more successful in operating the magnet than Oxford Instrument because of the care that I took in developing procedures. I also identified and corrected a major problem (thermo-acoustic oscillations) in the flight transfer system that Oxford had not detected and that, under certain operating conditions, could reduce the cryogen hold time by a factor of 2.

In parallel with the magnet tests, I worked on the final test assembly of the ISOMAX detector stack and instrumentation. This parallel approach allowed us to save a great deal of time and gave over a month of running the instrumentation with ground-level cosmic ray muons prior to the full payload integration.

In March, 1998, we integrated the magnet with the payload. I both participated in and supervised this effort. The integration was complete at the end of March, and we operated the instrument with the magnet on for more than a month. We also carried out environmental testing of the instrument between 0 °C and 40 °C. The laboratory tests confirmed the excellent performance of the instrument and its readiness for flight. The only real problem that was encountered involved the LeCroy 2259B peak sensing ADCs used for the Cherenkov detector. These proved to have an odd magnetic field sensitivity as well as an oscillation problem when connected to our preamplifiers, which incorporate a built-in voltage offset. I was able to identify a design problem with the 2259B which generated both of these problems. My solution to the problem both corrected the

difficulties that we had and slightly improved the overall performance of the units. This fix may be included in future issues of the ADC.

The final issue which ISOMAX had to face before shipping to Canada was a redesign of the suspension system which was requested by the National Scientific Balloon Facility. We were able to complete the redesign and initial parts fabrication before leaving for Canada. Unfortunately, we had to complete the installation in Canada. Again, I supervised this effort and collaborated on the engineering.

The ISOMAX instrument itself was shipped to Canada in a very complete state. The instrument was running and taking ground muon data within 3 days of unloading. This was a remarkable achievement. Full integration of the payload mechanical and electrical systems took considerably longer, and we were only ready for compatibility testing with the NSBF crew on August 3. As with the work at GSFC, I was in charge of the integration of the instrument in Canada as well as carrying out a great deal of the work myself.

The instrument was launched at 07:50 on August 4, 1998, and landed near Peace River, Alberta, Canada at about 17:00 on August 5. The performance of the instrument in flight was excellent and we were extremely pleased with the quality of the data. The climb-out took about 3 hours and we spent about 2 hours at float altitude tuning the detector and trigger systems. Unfortunately, we began to have problems shortly after we completed the tune-up. The payload control circuitry (either GSFC or NSBF) caused problems and the payload turned itself off a number of times while in flight although, fortunately, we were able to recover each time. In addition, the payload flew over a very large thunderstorm and the altitude drooped from the nominal float altitude of 126 thousand feet to about 100 thousand feet. As a result of these problems, we will ultimately have about 16 hours of good data at high altitude. The low altitude data will not be lost, however, and will be of great value in understanding atmospheric corrections to the ISOMAX data.

We proposed a continuation of the ISOMAX effort to NASA in Spring, 1998. The scientific and technical reviews were excellent but there was some confusion about the capabilities of the AMS experiment to carry out the ISOMAX science goals. At this point we have been approved to fly ISOMAX for 3 days in 2000. This flight will use low power electronics developed at GSFC and the collaborating institutions.

We consider the ISOMAX development and flight to have been a great success. It is a uniquely capable instrument with 3 to 5 times the performance of any magnetic spectrometer either in existence or planned. It is a tribute to the hard work and dedication of the whole ISOMAX team.

OWL: I am leading focal plane detector definition studies for the Orbiting Wide-Field Light-Collector (OWL) satellite for detecting ultra-high-energy cosmic particles and have a major involvement in the OWL trigger/electronics development. OWL, which is under study by a GSFC-led collaboration, will study the energy, arrival direction, and interaction characteristics of the highest energy ($>10^{20}$ eV) individual particles yet observed. The origin of particles at these energies is poorly understood and their measurement will yield important insights into the fundamental physics of ultra-high-energy astrophysical processes.

The flux of cosmic rays at these energies is on the order of one per square kilometer per century. Thus, a huge detector is required to measure with any statistical significance in a limited amount of time. The OWL concept makes use of the Earth's atmosphere as a huge calorimeter by observing particle showers produced by energetic particles in the atmosphere. These showers are detected and measured by looking at the UV light from the ionization fluorescence of atmospheric nitrogen resulting from the passage of shower particles. This is accomplished by a space based optical system with a collecting aperture of several square meters looking down into the atmosphere. Depending on the detector configuration, OWL may observe as many as a million square kilometers at one time. OWL must detect and measure the shower tracks over a large area of atmosphere and in the presence of significant light contamination. Particular challenges are the spacecraft, the optical system, the trigger/electronics, and the focal plane detector.

During the past year, I concentrated on developing a full strawman focal plane detector for OWL and on beginning development of the detector working with engineers from GSFC. I presented this work at the November, 1997 workshop "Observing Giant Cosmic Ray Air Showers From $>10^{20}$ eV Particles from Space." The work is published in the proceedings of this conference. I also presented my work at an October, 1998 joint meeting of the OWL and AIRWATCH collaborations. AIRWATCH is an Italian-led collaboration which shares the OWL goals. It is probable that the OWL and AIRWATCH collaborations will be combined at some future date.

PAMELA: This is a compact magnet spectrometer experiment under development by an Italian-led international collaboration which includes researchers from Germany, Sweden, Russia, and the United States. The instrument is approved for flight on board a Russian satellite "Resurs-Arktika" which will fly at the end of 2002 or early in 2003. I am a member of the governing science and technical boards for PAMELA and am the head of the trigger subgroup. I am leading the development of the time-of-flight system by a team composed of scientists and engineers from GSFC, New Mexico State University, and the University of Siegen,

Germany. I am also a consultant on photon detectors for the anti-coincidence system.

During the past year, the TOF team continued working on the design of the detector and the mechanical interfaces. I attended an engineering/science meeting in Rome during December, 1997. At the December meeting, I presented the current TOF design and the prospects for US funding as well as leading the discussion on trigger issues..

I have been working with a GSFC engineer, Larry Ryan, on the low power time and amplitude digitizers to be used on PAMELA. This work is sufficiently similar to that underway for the long-duration future flights of ISOMAX that both experiments will benefit.

Together with New Mexico State University, we submitted a proposal to the Mission of Opportunity section of the 1998 NASA UNEX AO. The proposal received excellent ratings for its scientific and technical content from both the Sun-Earth Connection and the Structure and Evolution of the Universe subcommittees. The last program to receive such dual excellents was ACE. Despite this, PAMELA was not funded, partly due to its Russian connection.

We have been given permission to pursue PAMELA using SR&T funds and I will be the US Principal Investigator for all future PAMELA work. We have asked for considerable GSFC engineering support and have a good prospect of it being granted. We will propose additional NASA support for fabrication of the flight hardware in response to the NASA MIDEX AO expected in Fall, 1999.

CAPRICE98: The Cosmic Antiparticle Ring Imaging Cherenkov Experiment 1998 (CAPRICE98), which flew in Spring, 1998, is the current effort of the WiZard Collaboration and is directed toward the measurement of high-energy (4-20 GeV) cosmic ray antiprotons. I have leading roles in the scientific and instrumental direction of this collaboration (I am a member of the advisory board).

During the past year, I worked on the TOF detector system and the event trigger electronics for CAPRICE 98. The TOF system was based on the earlier TOF which I had built for TS93 and CAPRICE94. It is expected that the next flight of CAPRICE will take place in Spring or Fall, 1999.

TIGER, ACCESS ZIM: These are respectively a balloon-borne and a proposed space station based experiment to study the elemental composition of the cosmic radiation for charges greater than 26. The Trans-Iron Galactic Element Recorder (TIGER) is essentially a proof-of-technique vehicle in preparation for a space borne investigation. Two previous flight attempts have met with balloon failure, and TIGER flew from Ft. Sumner, NM in Fall, 1997.

TIGER has been selected as the demonstration payload for the NASA Ultra-long-duration Balloon Program (ULDB). TIGER 2000 will fly in Winter 2000/2001 from New Zealand. The payload is currently being modified for this flight.

My principal role in the TIGER experiment is as an expert in time-of-flight measurements and in general experiment design.

The charge module for Advanced Cosmic Composition Experiment for the Space Station (ACCESS) mission is now known as ZIM (Z Identification Module) and is currently funded for study. The ZIM collaboration (Washington University, Caltech, JPL, GSFC, NRL, and University of Minnesota) are currently carrying out several development projects in support of ACCESS. I am responsible for the accelerator test plan and for the TOF. If ZIM is successful in participating in ACCESS, I expect to be responsible for the TOF detectors and electronics.

ACCESS Calorimeter: One of the three major instruments to fly on ACCESS will be a large calorimeter to measure the light cosmic ray composition to energies approaching 10^{15} eV. A number of calorimeter designs were proposed for study and are currently being evaluated by a simulation team led by Dr. Jonathan Ormes of GSFC and by an accelerator test/calibration team which I lead. In addition, Jon Ormes, Alex Moiseev, and I have been studying how best to use the calorimeter to measure high-energy electrons as well as general optimization issues. We expect these studies to lead to a proposal to construct the actual flight calorimeter in collaboration with a team of researchers at universities and other national laboratories.

General Description of Independent Research

Independent of GSFC, I am engaged both in astrophysical research and in a very active and wide ranging program of accelerator-based experimental high-energy nuclear and elementary particle physics. I designed and managed large parts of the Superconducting Magnet Instrument for Light Isotopes (SMILI) cosmic ray experiment and the Lawrence Berkeley National Laboratory (LBNL) E683H, E849H, and E938H (Transport), and BNL E878 and E896 nuclear physics experiments. I designed and built detector systems and experiment electronics for these experiments as well as for the BNL E866 and LBNL E859H nuclear/particle physics programs. I have also developed and tested a number of advanced detectors and contributed to many successful experiment proposals.

My astrophysics research has involved experimental cosmic ray investigations (e.g. SMILI), the development of new detector techniques (e.g. LArC - Liquid Argon Calorimetry), and the measurement of astrophysically important nuclear interaction parameters. The latter effort, mainly using the LBNL Bevatron heavy-ion accelerator, has been directed toward measuring interaction rates and production probabilities (cross-sections) of nuclei and particles in nucleus-nucleus collisions at

astrophysical energies. The focus of this effort is now shifting toward understanding the fundamental nuclear physics involved in these interactions.

Recently my main research effort in nuclear/particle physics, using the BNL AGS, has been aimed at the measurement of antiparticle and antinucleus production cross-sections and searches for exotic particles produced under the extreme conditions of nuclear density and temperature present in the interaction of a high-energy heavy-ion beam with a massive nuclear target. This work probes energy regimes which have not existed since shortly after the Big-Bang. We are finalizing the interpretation of BNL experiment E878 which measured antinucleus production and searched for "strange quark matter", i.e. charged particles with mass/charge ratios $\gg 2$.

Currently, my focus is on BNL experiment E896 (described below). After 1998, my effort will shift to work on the Solenoidal Tracker at RHIC (STAR) instrument at the BNL Relativistic Heavy-Ion Collider (RHIC). My work on E896 and STAR is supported by the Department of Energy through a Visiting Research Scientist position in nuclear physics at Johns Hopkins University. This work is of great benefit to GSFC since by working at the cutting edge of nuclear and particle physics research I maintain and enlarge my expertise in state-of-the-art instruments and detector systems.

Summary of the E896 Experiment

E896 is primarily designed to search for the H^0 dibaryon, a short lived ($c\tau \sim 4$ cm) neutral six quark particle (uuddss MIT bag) that is predicted to be produced in great numbers in heavy-ion central collisions. The H^0 is the focus of several major experiments but has not yet been detected. E896 is conducting the most sensitive test of the H^0 predictions to date by searching for a unique decay topology using two tracking systems, a finely segmented gas drift chamber and a solid state (silicon) drift array. In addition, E896 will make unique measurements of the production of other short-lived neutral (e.g. Λ) and charged particles in central collisions. The E896 experiment has had engineering runs in December, 1996/January, 1997, using an 11.6 GeV/nucleon Au beam, and in June 1997, using a 21 GeV proton beam, was carried out in June, 1997. Physics runs have been conducted in April, 1998, with the 11.6 GeV/nucleon Au beam, and in September, 1998 with the 21 GeV proton beam.

I have a central role in E896. I am responsible for the fast event trigger electronics and for the high-rate trigger detectors. I contributed to the superconducting magnet, drift chamber, TOF system, and numerous other experiment components. I played a major part in the design and execution of all experimental runs. In all runs,

the trigger systems that I designed and implemented consistently performed at the high level required.

In addition to fast Cherenkov-based beam counters, the trigger detector system includes two other highly specialized detectors for which I am responsible. These are used by the trigger logic to determine, in less than 100 nanoseconds, the impact geometry (centrality) of a particular nuclear collision. Since central collisions yield the highest nuclear temperatures and densities, this allows the experiment to record a dataset which is enriched by a factor of about 100 over a beam trigger.

The primary centrality detector, the Multiplicity Telescope (MLT), determines the number of particles created in the beam/target interaction to provide a measure of the "violence" of the collision. The detector is located "downstream" of the interaction target in the bore of the 7 Tesla sweeper magnet and makes innovative use of waveshifting optical fibers to read out an array of thin lead/scintillator detectors. These detect high energy photons (gamma rays) arising from the decay of primary neutral pions from the collision. I designed and built this detector making use of sensitivity models which I developed with a post-doctoral researcher, Zoran Milosovitch, at Carnegie Mellon University. In addition to its use in E896, the MLT has served as the prototype for the baseline anticoincidence system developed at GSFC for the GLAST gamma ray telescope.

The MLT is supplemented by an "External Charge Detector" (ECD) which measures the charge of outgoing "beam like" fragments produced by the breakup of the incident beam nucleus. The absence of large ($Z > 2$) fragments indicates a central collision.

For the September, 1998, proton run, I designed and implemented a new trigger system using the TOF wall to tag interactions. This maximized the science return in the low particle-multiplicity environment resulting from the p-Au collisions. At present E896 is considering whether to conduct a final run in Spring, 1999.

INVITED TALKS

1998 - "Particle Measurement Techniques," 1998 Workshop on Balloon-Borne and Space-Based Calorimetry, Texas Tech University, Lubbock, Texas.

Papers Published or Accepted for Publication:

Note: Most of my research is carried out in conjunction with relatively large collaborations. To reduce the length of the report, I have noted the collaboration or experiment name associated with each paper rather than listing the co-author affiliations. The latter appear in Appendix A.

1999 - "Large-Area Scintillating-Fiber Time-of-Flight/Hodoscope Detectors for Particle Astrophysics Experiments", D. J. Lawrence, L. M. Barbier, J. Beatty, W. R. Binns, E. R. Christian, D. J. Crary, D. J. Ficenec, P. L. Hink, J. Klarmann, K. E. Krombel, J. W. Mitchell, B. F. Rauch, S. H. Sposato, R. E. Streitmatter, and C.J. Waddington, NIM (in press). **TIGER Collaboration**

1999 - "Neutron production in coincidence with fragments from the $^{40}\text{Ca}+\text{H}$ Reaction at $E_{\text{lab}} = 357\text{A}$ and 565A MeV ", A. Insolia, C. Tuvé, S. Albergo, D. Boemi, Z. Caccia, C.-X. Chen, S. Costa, H.J. Crawford, M. Cronqvist, J. Engelage, P. Ferrando, L. Greiner, T.G. Guzik, C.N. Knott, P.J. Lindstrom, J.W. Mitchell, R. Potenza, S. Reito, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C.E. Tull, C.J. Waddington, W.R. Webber, and J.P. Wefel, Phys. Rev. C, (in press, January 1999). **TRANSPORT Collaboration.**

1998 - "Measurement of Low-Energy Cosmic-Ray Antiprotons at Solar Minimum," H. Matsunaga, S. Orito, H. Matsumoto, K. Yoshimura, A. Moiseev, K. Anraku, R. Golden, M. Imori, Y. Makida, J. Mitchell, M. Motoki, J. Nishimura, M. Nozaki, J. Ormes, T. Saeki, T. Sanuki, R. Streitmatter, J. Suzuki, K. Tanaka, I. Ueda, N. Yajima, T. Yamagami, A. Yamamoto, and T. Yoshida, Phys. Rev. Lett. **81**, 4052. **BESS Collaboration.**

1998 - "Photodetectors for OWL", J. W. Mitchell, AIP Conference Proceedings **433**, 500.

1998 - "The Cosmic Ray $^3\text{He}/^4\text{He}$ Ratio from 200 MeV/nucleon to 3.7 GeV/nucleon", O. Reimer, W. Menn, M. Hof, M. Simon, A.J. Davis, A.W. Labrador, R.A. Mewaldt, S.M. Schindler, L.M. Barbier, E.R. Christian, K.E. Krombel, J.W. Mitchell, J.F. Ormes, R.E. Streitmatter, R.L. Golden, S.J. Stochaj, and W.R. Webber, Ap. J. **496**, 490. **IMAX Collaboration.**

1997 - "Momentum spectra of atmospheric pions, muons, electrons and positrons at balloon altitudes," A. Codino, M.T. Brunetti, C. Federico, C. Grimani, M. Lanfranchi, M. Menichelli, M. Miozza, R.L. Golden, S.J. Stochaj, S.A. Stephens, J.W. Mitchell, J.F. Ormes, R.E. Streitmatter, M. Hof, C. Pfeifer, W. Menn, M. Simon, G. Basini, M. Ricci, F.M. Brancaccio, P. Papini, S. Piccardi, P. Spillantini, M.P. DePascale, A. Morselli, P. Picozza, J. PHYS. **G23**, 1751. **WiZard Collaboration.**

1997 - "A New Limit on the Flux of Cosmic Antihelium," T. Saeki, K. Anraku, S. Orito, J. Ormes, R. Golden, M. Imori, S. Inaba, B. Kimball, N. Kimura, Y. Makida, H. Matsumoto, H. Matsunaga, J. Mitchell, M. Motoki, J. Nishimura, M. Nozaki, R. Streitmatter, J. Suzuki, K. Tanaka, I. Ueda, N. Yajima, T. Yamagami, A. Yamamoto,

T. Yoshida, and K. Yoshimura, Phys. Lett. **B422**, 319. **BESS Collaboration**.

1997 - "Study of the combined particle identification capability of a transition radiation detector and a silicon imaging calorimeter during the TS93 balloon flight," R. Bellotti, A.F. Cafagna, M. Castellano, M. Circella, G. De Cataldo, C. De Marzo, N. Giglietto, B. Marangelli, A. Raino, P. Spinelli, F. Massimo Brancaccio, M. Grandi, P. Papini, A. Perego, S. Piccardi, P. Spillantini, G. Basini, M. Ricci, A. Codino, N. Finetti, C. Grimani, V. Bidoli, M. Candusso, M. Casolino, M.P. De Pascale, F. Aversa, G. Barbiellini, M. Boezio, A. Colavita, F. Fratnik, P. Schiavon, A. Vacchi, N. Zampa, J.W. Mitchell, R.E. Streitmatter, R.L. Golden, S.J. Stochaj, M. Hof, W. Menn, M. Simon, and S.A. Stephens, *Astroparticle Phys.* **7**, 219. **WiZard Collaboration**.

1997 - "Performance of CAMAC TDC and ADC in Magnetic Field," S.K. Gupta, L.M. Barbier, E.R. Christian, S. Geier, J.F. Krizmanic, J.W. Mitchell, R.E. Streitmatter, and P.J. Wasilewski, *Nucl. Inst. and Methods A* **400**, 428. **All authors NASA/GSFC**. Also: E.R. Christian, J.F. Krizmanic and J.W. Mitchell USRA, S.K. Gupta NAS/NRC, S. Geier University of Maryland, College Park.

1997 - "Antiproton distributions in Au+nucleus collisions," M. Bennett, D. Beavis, J.B. Carroll, J. Chiba, A. Chikanian, H.J. Crawford, M. Cronqvist, Y. Dardenne, R. Debye, T. Doke, J. Engelage, L. Greiner, T.J. Hallman, R.S. Hayano, H.H. Heckman, T. Kashiwagi, J. Kikuchi, S. Kumar, C. Kuo, P.J. Lindstrom, J.W. Mitchell, S. Nagamiya, J.L. Nagle, J.K. Pope, P. Stankus, K.H. Tanaka, R.C. Welsh, and W. Zhan, *Phys. Rev.* **C56**, 1521. **E878 Collaboration**.

1997 - "Systematics of Isotopic Production Cross Sections from Interactions of Relativistic ^{40}Ca in Hydrogen", C.-X. Chen, S. Albergo, Z. Caccia, S. Costa, H.J. Crawford, M. Cronqvist, J. Engelage, P. Ferrando, R. Fonte, L. Greiner, T.G. Guzik, A. Insolia, C.N. Knott, P.J. Lindstrom, J.W. Mitchell, R. Potenza, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C.E. Tull, C. Tuvé, C.J. Waddington, W.R. Webber, J.P. Wefel, and X. Zhang, *Phys. Rev.* **C56**, 1536. **TRANSPORT Collaboration**.

1997 - "Interactions of Relativistic ^{36}Ar and ^{40}Ar Nuclei in Hydrogen: Isotopic Production Cross Sections", C.N. Knott, S. Albergo, Z. Caccia, C.-X. Chen, S. Costa, H.J. Crawford, M. Cronqvist, J. Engelage, P. Ferrando, R. Fonte, L. Greiner, T.G. Guzik, A. Insolia, P.J. Lindstrom, J.W. Mitchell, R. Potenza, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C.E. Tull, C. Tuvé, C.J. Waddington, W.R. Webber, J.P. Wefel, and X. Zhang, *Phys. Rev.* **C56**, 398. **TRANSPORT Collaboration**

1997 - "Neutron production at 0 degrees from the $^{40}\text{Ca}+\text{H}$ Reaction at $E_{\text{lab}} = 357\text{A}$ and 565A MeV", C. Tuvé, S. Albergo, D. Boemi, Z. Caccia, C.-X. Chen, S. Costa, H.J. Crawford, M. Cronqvist, J. Engelage, P. Ferrando, L. Greiner, T.G. Guzik, A. Insolia, C.N. Knott, P.J. Lindstrom, J.W. Mitchell, R. Potenza, S. Reito, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C.E. Tull, C.J. Waddington, W.R. Webber, and J.P. Wefel, Phys. Rev. **C56**. 1057. **TRANSPORT Collaboration**

1997 - "A Heavy Ion Spectrometer System Used for the Measurement of Projectile Fragmentation of Relativistic Heavy Ions", S. Albergo, Z. Caccia, C.-X. Chen, S. Costa, H.J. Crawford, M. Cronqvist, J. Engelage, P. Ferrando, R. Fonte, L. Greiner, T.G. Guzik, A. Insolia, C.N. Knott, P.J. Lindstrom, J.W. Mitchell, R. Potenza, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C.E. Tull, C. Tuvé, C.J. Waddington, W.R. Webber, J.P. Wefel, and X. Zhang, Radiat. Meas. **27**, 549. **TRANSPORT Collaboration**

Papers submitted but not yet Accepted for Publication:

1999 - "A Measurement of the Isotopic Composition of Cosmic Ray Helium, Lithium, Beryllium, and Boron up to $1700\text{ MeV}/\text{amu}$ ", S.P. Ahlen, N.R. Greene, D. Loomba, J.W. Mitchell, C.R. Bower, R.M. Heinz, S.L. Mufson, J. Musser, J.J. Pitts, G.M. Spiczak, J. Clem, T.G. Guzik, M. Lijowski, J.P. Wefel, S. Mckee, S. Nutter, A. Tomasch, J.J. Beatty, D.J. Ficenecc, and S. Tobias, Ap. J. (submitted). **SMILI Collaboration**.

1999 - "The cosmic ray proton and helium spectra between 0.4 and 200 GV," M. Boezio, P. Carlson, T. Francke, N. Webber, M. Suffert, M. Hof, W. Menn, M. Simon, S.A. Stephens, R. Bellotti, F. Cafagna, M. Castellano, M. Circella, C. De Marzo, N. Finetti, P. Papini, S. Piccardi, P. Spillantini, M. Ricci, M. Casolino, M.P. De Pascale, A. Morselli, P. Picozza, R. Sparvoli, G. Barbiellini, U. Bravar, P. Schiavon, A. Vacchi, N. Zampa, J.W. Mitchell, J.F. Ormes, R.E. Streitmatter, R.L. Golden, and S.J. Stochaj, Ap.J. (submitted). **WiZard Collaboration**.

1999 - "Neutron production from the $^{40}\text{Ca}+\text{H}$ Reaction at $E_{\text{lab}} = 357\text{A}$ and 565A MeV", A. Insolia, C. Tuvé, S. Albergo, D. Boemi, Z. Caccia, C.-X. Chen, S. Costa, H.J. Crawford, M. Cronqvist, J. Engelage, P. Ferrando, L. Greiner, T.G. Guzik, C.N. Knott, P.J. Lindstrom, J.W. Mitchell, R. Potenza, S. Reito, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C.E. Tull, C.J. Waddington, W.R. Webber, and J.P. Wefel, Adv. Nucl. Dynamics (submitted). **TRANSPORT Collaboration**

Papers Presented at Scientific Meetings:

Papers Published in Conference Proceedings.

1998 - "BESS Measurement of Cosmic-Ray Antiproton Spectrum and Search for Antimatter," S. Orito, T. Maeno, H. Matsunaga, K. Abe, K. Anraku, Y. Asaoka, M. Fujikawa, M. Imori, N. Matsui, M. Motoki, T. Saeki, T. Sanuki, Y. Shikaze, T. Sonoda, I. Ueda, K. Yoshimura, Y. Makida, J. Suzuki, K. Tanaka, A. Yamamoto, T. Yoshida, H. Matsumoto, T. Mitsui, M. Nozaki, M. Sasaki, J. Mitchell, A. Moiseev, J. Ormes, R. Streitmatter, J. Nishimura, Y. Yajima, T. Yamagami, E.S. Seo, and M. Ishino, Proceedings of ICHP '98.

Other Conference Papers

1998 - "A Measurement of Cosmic Ray Deuterium from 0.2-3.0 GeV/nuc", Columbus, April, Bull. Am. Phys. Soc. APR98.

1998 - "A Balloon Flight of the Trans-Iron Galactic Element Recorder (TIGER) Experiment", Columbus, April, Bull. Am. Phys. Soc. APR98.

1998 - "A Time-Of-Flight System for BNL-AGS Experiment 896", Meeting of the Division of Nuclear Physics, Sante Fe, October, Bull. Am. Phys. Soc. DNP98.

1998 - "Hyperon Polarization Study and the Search for the H0 Dibaryon with the E896 Distributed Drift Chamber", Meeting of the Division of Nuclear Physics, Sante Fe, October, Bull. Am. Phys. Soc. DNP98.

1998 - "Charged particle measurement in Au+Au collisions with the silicon drift detector array from AGS experiment E896", Meeting of the Division of Nuclear Physics, Sante Fe, October, Bull. Am. Phys. Soc. DNP98.

1998 - "BNL E896--Data Acquisition", Meeting of the Division of Nuclear Physics, Sante Fe, October, Bull. Am. Phys. Soc. DNP98.

1998 - "An electronic clock for correlated noise measurements in BNL-AGS Experiment 896", Meeting of the Division of Nuclear Physics, Sante Fe, October, Bull. Am. Phys. Soc. DNP98.

1998 - "BNL E896--Search for Strangeness = -2 di-baryons", Meeting of the Division of Nuclear Physics, Sante Fe, October, Bull. Am. Phys. Soc. DNP98.

University Collaborations:

I am a member of a number of collaborations including researchers from U.S. and foreign universities. At present, I am working particularly closely with the California Institute of Technology and the University of Siegen (Germany) on ISOMAX development and with Johns Hopkins University, Rice University,

Carnegie Mellon University, and University of California - Berkeley on the E896 experiment (many other universities are involved in E896 as well). I am working closely with New Mexico State University and University of Siegen (Germany) on CAPRICE and PAMELA.

During the past year, I have been the primary mentor for Sven Geier, a graduate student at the University of Maryland College Park who is basing his PhD on ISOMAX. Sven has worked with me on the ISOMAX time-of-flight systems and on the ISOMAX flight. Sven is currently analyzing data from the August, 1998, ISOMAX flight. I have also worked closely with Thomas Hams and Holger Goebel of the University of Siegen, who are pursuing PhDs based on ISOMAX.

In the course of my work on the BNL E896 experiment, I have worked closely with and helped direct the experimental efforts of Kris Kainz from Rice University. Under my direction, Kris Kainz built and tested the E896 Exit Charge Detector (ECD) Cherenkov detector system which I designed. This work and the analysis of the performance of the detector was the basis for a MS degree. Kris is now pursuing a Ph.D. from E896 work.

As part of my E896 work, I helped direct the efforts of a postdoctoral researcher, Zoran Milosovitch at Carnegie Mellon University on design and operation of the Multiplicity Telescope detector system. I also trained several of the E896 graduate students in the design and operation of the experiment trigger. I have worked most closely with Sean Kelly of UCLA and Gaspare Lo Curto of Ohio State. Under my direction, Gaspare developed and implemented the part of the E896 trigger which was specific to the Silicon Drift Detector Array (SDDA).

I continued my close collaboration with Dr. Leon Madansky at Johns Hopkins University. My appointment as a Visiting Research Scientist in the Department of Physics and Astronomy at Johns Hopkins University aids my collaboration with JHU on the Brookhaven E878, E896, and STAR experiments and provides me with access to JHU facilities and shops.

Some of the U.S. universities with which I collaborate actively and the projects with which they are associated are:

University of Alabama (*OWL* - R. Chipman, J. Dimmock, Y. Takahashi)

University of Arizona (*IMAX, POEMS* - T. Bowen, J.R. Jokipii)

Boston University (*SMILI* - S. Ahlen, N. B. Zhou)

University of California - Berkeley (*Transport, E878, E896, STAR, GMSD* -- M. Bennett, H. Crawford, M. Cronqvist, J.

Engelage, L. Greiner, H. Heckman, V. Lindenstruth, E. Judd, G. Visser)

California Institute of Technology (*IMAX, ISOMAX, TIGER, ZIM/ACCESS* - A. Davis, R. Mewaldt, S. Schindler, E. Stone)

University of California - Los Angeles (*E878, E896, STAR* - J. Carroll, V. Ghazikhanian, H. Huang, G. Igo, B. Lasiuk, S. Trentalange)

Carnegie Mellon University (*E896, STAR* - C. Brown, M. Kaplan, P. Karol, Z. Milosevich, J. Whitfield)

University of Chicago (*ACCESS* - D. Mueller, S. Swordy)

Columbia University (*E878* - S. Nagamiya)

University of Delaware/Bartol Research Institute (*POEMS, SMILI* - J. Clem, P. Evenson, J. L'Heureux, G. Spiczak)

Indiana University (*SMILI* - C. Bower, R. Heinz, S. Mufson, J. Musser)

Johns Hopkins University (*E878, E896, STAR* - L. Madansky)

Louisiana State University (*Transport, ACCESS* - M. Cherry, T.G. Guzik, J. Isbert, J. Wefel)

University of Louisville (*GMSD* - W. Pitts, K. Walsh)

University of Maryland (*BESS, ACCESS Calorimeter* - F. McDonald, O. Ganil, E. Seo)

University of Michigan (*SMILI, E878, E896* - S. Mckee, G. Tarle, A. Tomasch, R. Welsh), University of New Hampshire

New Mexico State University (*IMAX, WiZard, PAMELA* - S. Stochaj, W. Webber)

Eastern New Mexico University (*SMILI* - S. Nutter)

University of Minnesota (*Transport, TIGER, ZIM/ACCESS* - C.J. Waddington)

Ohio State University (*E896, STAR* - T. Humanic, E. Sugarbaker, I. Kotov)

Pennsylvania State University (*SMILI, TIGER, ACCESS* - J.J. Beatty, S. Coutu)

Rice University (*E896, STAR* - B. Bonner, W. Llope, E. Platner, P. Yepes)

Southern University (*POEMS* - D. Bagayoko, G. Joshi)

Texas Tech (*ACCESS* - A. Sill, R. Wigmans)

University of Texas - Austin (*E896, STAR* - G. Hoffman, F. Moore, P. Riley, J. Schambach)

University of Utah (*OWL* - E. Loh, P. Sokolsky, P. Sommers)

Wayne State University (*E896, STAR* - R. Bellwied, S. Pandey, K. Wilson)

Washington University - St. Louis (*TIGER, ZIM/ACCESS* - R. Binns, J. Klarmann)

Yale (*E878, E896, STAR* - V. Bernardo, J. Harris, B.S. Kumar, G. Kunde, f. Rotondo, N. Smirnov, Z. Xu).

Foreign universities with which I collaborate include:

University of Bari (Italy - *WiZard, PAMELA* - R. Bellotti, F. Cafagna, M. Castellano, M. Cirecella, C. De Marzo)

University of Catania (Italy - *Transport, E896* - S. Albergo, D. Boemi, Z. Caccia, S. Costa, A. Insolia, C. Nociforo, R. Potenza, A. Tricomi, C. Tuve)

Ehime University (Japan - *LArC*)

University of Firenze (Italy - *WiZard, PAMELA* - G. Castellini, P. Papini, S. Piccardi, P. Spillantini)

University of Kiel (Germany - *POEMS* - W. Droge, B. Heber, H. Kunow, R. Mueller-Mellin)

Kobe University (Japan - *BESS* - H. Matsumoto, M. Motoki, M. Nozaki)

McGill University (Canada - *E896* - J. Barrette, T. Mark)

The University of Perugia (Italy - *WiZard, PAMELA*)

Saitama College (Japan - *LArC*)

University of Siegen (Germany - *IMAX, ISOMAX, WiZard, ZIM/ACCESS, PAMELA* - M. Hof, W. Menn, M. Simon)

University of Trieste (Italy - *ACCESS Calorimeter, WiZard, PAMELA* - G. Barbiellini, P. Schiavon, A. Vacci, N. Zampa)

University of Tokyo (Japan - *E878, LArC, BESS* - R. Hayano, M. Imori, H. Matsunaga, S. Orito, T. Saeki, I. Ueda, T. Yoshida, K. Yoshimura)

Universita Tor Vergata (Italy - *WiZard, PAMELA* - M. Casolino, M.P. De Pascale, A. Morselli, P. Picozza, R. Sparvoli)

Waseda University (Japan - *LArC*).

As a member of the STAR (Solenoidal Tracker at RHIC) collaboration, I work with researchers from 15 U.S. and 6 foreign universities, some of which are listed above.

During the past year, I traveled to the University of Rome (Roma 2) and to Johns Hopkins University to work on collaborative activities.

Other Collaborative Activities:

Many of my research collaborations involve non-university researchers. These are listed under the descriptions of my activities. Some of the involved institutions and personnel involved include:

A.F. Ioffe Institute of Physics and Technology (Russia - *PAMELA*)

Brookhaven National Laboratory (*E878, E896, STAR* - D. Beavis, W. Christie, R. Debbe, T. Hallman, T. Ljubicic, R. Longacre, D. Lynn, J.T. Mitchell, E. Mogavero, A. Saulys)

CEBAF (*GMSD*- H. Fenkar, S. Majewski)

CEN-Saclay (France - *Transport* - A. Soutoul, O. Testard)

CERN (France/Switzerland -*E896, Star* - M. Gotra, P. Sonderegger)

CRN Strasbourg (France - *WiZard* - M. Suffert)

INFN - Frascati (Italy - *WiZard, PAMELA* - M. Ricci)

Institute for Space and Astronomical Science (ISAS - Japan - *BESS* - J. Nishimura, N. Yajima, T. Yamagami)

Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (Russia - *PAMELA*)

Jet Propulsion Laboratory (*IMAX, ISOMAX, TIGER, ZIM/ACCESS* - E. Stone, M. Widenbeck)

Lawrence Berkeley National Laboratory (*Transport, E878, E896, STAR* - D. Greiner, P. Lindstrom, J. Marx, I. Sakrejda, C. Tull)

Marshall Space Flight Center (*OWL* - M. Christl, T. Parnell)

Moscow Engineering Physics Institute (Russia - *PAMELA*)

National Laboratory for High Energy Physics (KEK - Japan - *BESS* - K. Anraku, S. Inaba, N. Kimura, Y. Makida, J. Suzuki, K. Tanaka, A. Yamamoto)

Royal Institute of Technology (Sweden - *WiZard* - P. Carlson, T. Francke)

Tata Institute (India - *WiZard*, *ISOMAX* - S. Gupta, S. Stephens)

In addition, the STAR collaboration involves researchers from 4 national laboratories.

During the past year, I traveled to Brookhaven National Laboratory to work on collaborative projects.

Papers in preparation for refereed journals:

Some titles and author lists are provisional.

"Performance of the Isotope Matter-Antimatter Experiment Balloon-Borne Magnetic Spectrometer," J.W. Mitchell, L.M. Barbier, E.R. Christian, J.F. Krizmanic, K. Krombel, J.F. Ormes, R.E. Streitmatter, A.W. Labrador, A. Davis, R.A. Mewaldt, S.M. Schindler, E.C. Stone, R.L. Golden, S.J. Stochaj, W.R. Webber, W. Menn, M. Hof, O. Reimer, and M. Simon, in preparation for Nucl. Inst. and Meth.

"The Spectra of Cosmic Ray Hydrogen and Helium," W. Menn, M. Hof, O. Reimer, M. Simon, A. Davis, A.W. Labrador, R.A. Mewaldt, S.M. Schindler, E.C. Stone, L.M. Barbier, E.R. Christian, K. Krombel, J.W. Mitchell, J.F. Ormes, R.E. Streitmatter, R.L. Golden, S.J. Stochaj, W.R. Webber, in preparation for Ap. J.

"Antiprotons in the Cosmic Radiation in the Energy Range from 0.25 to 3.2 GeV," A.W. Labrador, A. Davis, R.A. Mewaldt, S.M. Schindler, E.C. Stone, J.W. Mitchell, L.M. Barbier, E.R. Christian, J.F. Krizmanic, K. Krombel, J.F. Ormes, R.E. Streitmatter, R.L. Golden, S.J. Stochaj, W.R. Webber, W. Menn, M. Hof, O. Reimer, and M. Simon, in preparation for Ap. J.

"Energy Dependence of Isotopic Production Cross Sections from Projectile Fragmentation of Relativistic ^{32}S ," M. Cronqvist, C.E. Tull, S. Albergo, Z. Caccia, C.-X. Chen, S. Costa, H.J. Crawford, J. Engelage, P. Ferrando, R. Fonte, L. Greiner, T.G. Guzik, A. Insolia, F.C. Jones, C.N. Knott, P.J. Lindstrom, J.W. Mitchell, R. Potenza, J. Romanski, G.V. Russo, A. Soutoul, O. Testard, C. Tuve, C.J. Waddington, W.R. Webber, J.P. Wefel, in preparation for Phys. Rev. C.

"Low Energy ($E = 245$ MeV/nucleon) Fragmentation Cross Sections for ^{28}Si ," J. Isbert, H.J. Crawford, J. Engelage, T.G. Guzik, M. Hollier, P.J. Lindstrom, J.W. Mitchell, J. Neuhaus, W. Schimmerling, M. Simon, and J.P. Wefel, in preparation for submission to Phys. Rev. C.

"Production of Light Nuclei by Coalescence in Au+Au Central Collisions," D. Beavis, M. Bennett, J.B. Carroll, J. Chiba, A. Chikanian, H.J. Crawford, M. Cronqvist, Y. Dardenne, R. Debebe, T. Doke, J. Engelage, L. Greiner, T.J. Hallman, R.S. Hayano, H.H.

Heckman, T. Kashiwagi, J. Kikuchi, S. Kumar, C. Kuo, P.J. Lindstrom, J.W. Mitchell, S. Nagamiya, J.L. Nagle, J.K. Pope, P. Stankus, K.H. Tanaka, R.C. Welsh, and W. Zhan, in preparation for Phys. Rev. C.

"Pion and Kaon Production in Au+Au Collisions at 10.8 A GeV/c," D. Beavis, M. Bennett, J.B. Carroll, J. Chiba, A. Chikanian, H.J. Crawford, M. Cronqvist, Y. Dardenne, R. Debbe, T. Doke, J. Engelage, L. Greiner, T.J. Hallman, R.S. Hayano, H.H. Heckman, T. Kashiwagi, J. Kikuchi, S. Kumar, C. Kuo, P.J. Lindstrom, J.W. Mitchell, S. Nagamiya, J.L. Nagle, J.K. Pope, P. Stankus, K.H. Tanaka, R.C. Welsh, and W. Zhan, in preparation for Phys. Rev. Letters.

APPENDIX A: Members of Collaborations Represented in FY97 Publications

BESS Collaboration: K. Anraku³, R. Golden⁵, M. Imori⁴, S. Inaba³, B. Kimball⁵, N. Kimura³, Y. Makida³, H. Matsumoto¹, H. Matsunaga⁴, J. Mitchell², A. Moiseev², M. Motoki¹, J. Nishimura⁶, M. Nozaki¹, S. Orito⁴, J. Ormes², D. Righter², T. Saeki⁴, R. Streitmatter², J. Suzuki³, K. Tanaka³, I. Ueda⁴, N. Yajima⁶, T. Yamagami⁶, A. Yamamoto³, T. Yoshida⁴, and K. Yoshimura⁴.

¹Kobe University, Kobe, Japan

²NASA/Goddard Space Flight Center, Greenbelt, MD

³National Laboratory for High Energy Physics (KEK), Tsukuba, Ibaraki, Japan

⁴University of Tokyo, Tokyo, Japan

⁵New Mexico State University, Las Cruces, NM

⁶Institute for Space and Astronautical Science (ISAS) Sagami-hara, Kanagawa, Japan

E878 Collaboration: D. Beavis³, M. Bennett¹¹, J.B. Carroll⁴, J. Chiba⁵, A. Chikanian¹¹, H.J. Crawford², M. Cronqvist², Y. Dardenne², R. Debbe³, T. Doke⁶, J. Engelage², L. Greiner², T.J. Hallman⁴, R.S. Hayano¹, H.H. Heckman², T. Kashiwagi⁶, J. Kikuchi⁶, B.S. Kumar¹¹, C. Kuo², P.J. Lindstrom⁸, J.W. Mitchell⁹, S. Nagamiya¹⁰, J.L. Nagle¹¹, J.K. Pope¹¹, P. Stankus¹⁰, K.H. Tanaka⁵, R.C. Welsh^{7,12}, and W. Zhan¹⁰.

¹University of Tokyo, Japan.

²Space Sciences Laboratory, University of California-Berkeley.

³Brookhaven National Laboratory.

⁴University of California-Los Angeles.

⁵National Laboratory for High Energy Physics (KEK), Japan.

- ⁶Waseda University, Japan.
⁷Johns Hopkins University.
⁸Lawrence Berkeley Laboratory.
⁹USRA/GSFC.
¹⁰Columbia University.
¹¹Yale.
¹²University of Michigan

IMAX Collaboration: L.M. Barbier², E.R. Christian¹, J.F. Krizmanic¹, K. Krombel³, J.W. Mitchell¹, J.F. Ormes², R.E. Streitmatter², A.W. Labrador^{4,7}, A. Davis⁴, R.A. Mewaldt⁴, S.M. Schindler⁴, E.C. Stone⁴, R.L. Golden⁵, S.J. Stochaj⁵, W.R. Webber⁵, W. Menn⁶, M. Hof⁶, O. Reimer⁶, and M. Simon⁶.

¹Universities Space Research Association, NASA/GSFC, Greenbelt, MD

²NASA/GSFC, Greenbelt, MD

³NAS/NRC, NASA/GSFC, Greenbelt, MD

⁴California Institute of Technology, Pasadena, CA

⁵New Mexico State University, Las Cruces, NM

⁶Physics Department, University of Siegen, Siegen, Germany

⁷Physics Department, University of Chicago, Chicago, IL

ISOMAX Collaboration: L.M. Barbier², E.R. Christian¹, S. Geier⁶, S. Gupta³, J.F. Krizmanic¹, J.W. Mitchell¹, J.F. Ormes², R.E. Streitmatter², A. Davis⁴, G.A. DeNolfo⁴, R.A. Mewaldt⁴, S.M. Schindler⁴, E.C. Stone⁴, M. Bremerich⁵, H. Goebel⁵, T. Hams⁵, M. Hof⁵, W. Menn⁵, and M. Simon⁵.

¹Universities Space Research Association, NASA/GSFC, Greenbelt, MD

²NASA/GSFC, Greenbelt, MD

³NAS/NRC, NASA/GSFC, Greenbelt, MD 20771

⁴California Institute of Technology, Pasadena, CA

⁵Physics Department, University of Siegen, Siegen, Germany

⁶University of Maryland, NASA/GSFC, Greenbelt, MD

SMILI Collaboration: S.P. Ahlen⁶, J.J. Beatty², C.R. Bower⁵, J. Clem⁹, D.J. Ficene⁸, N.R. Greene⁶, T.G. Guzik¹, R.M. Heinz⁵, M. Lijowski⁸, D. Loomba⁶, J.W. Mitchell³, S.L. Mufson⁵, J. Musser⁵, S. Mckee⁴, S. Nutter⁷, J. Pitts⁵, G.M. Spiczak⁹, G. Tarle⁴, S. Tobias⁸, A. Tomasch⁴, J.P. Wefel¹, and B. Zhou.⁶

¹Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA

²Department of Physics, Penn State University, University Park, PA

³Universities Space Research Association, NASA/GSFC, Greenbelt, MD

⁴Randall Laboratory, Department of Physics, University of Michigan, Ann Arbor, MI

⁵Department of Physics and Astronomy, Indiana University, Bloomington, IN

⁶Department of Physics, Boston University, Boston, MA

⁷Department of Physical Sciences, Eastern New Mexico University, Portales, NM

⁸Department of Physics, Washington University, St. Louis, MO

⁹Bartol Research Institute, Newark, DE

TIGER Collaboration : D.J. Lawrence¹, L.M. Barbier⁵, J.J. Beatty³, W.R. Binns², E.R. Christian⁴, D.J. Crary¹, D.J. Ficene¹, P.L. Hink¹, J. Klarmann¹, K.E. Krombel⁵, J.W. Mitchell⁴, B.F. Rauch¹, S.H. Sposato¹, R.E. Streitmatter⁵, and C.J. Waddington⁶

¹Department of Physics, Washington University, St. Louis, MO

²McDonnell Center for Astrophysics, Washington University, St. Louis, MO

³Department of Physics, Penn State University, University Park, PA

⁴Universities Space Research Association, NASA/GSFC, Greenbelt, MD

⁵NASA/GSFC, Greenbelt, MD

⁶Tate Laboratory of Physics, University of Minnesota, Minneapolis, MN

Transport Collaboration: S. Albergo⁸, Z. Caccia⁸, C.-X. Chen³, S. Costa⁸, H.J. Crawford⁴, M. Cronqvist⁴, J. Engelage⁴, T.G. Guzik³, A. Insolia⁸, C.N. Knott⁵, P.J. Lindstrom⁴, M. McMahon³, J.W. Mitchell¹, R. Potenza⁸, G.V. Russo⁸, A. Soutoul⁷, O. Testard⁷, C.E. Tull⁴, C. Tuve⁸, C.J. Waddington⁵, W.R. Webber⁶, J.P. Wefel³, 1996, Ap. J. (submitted).

¹Universities Space Research Association, NASA/GSFC, Greenbelt, MD 20771

²Lawrence Berkeley Laboratory, Berkeley, CA

³Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA

⁴Space Science Laboratory, University of California, Berkeley, CA

⁵Tate Laboratory of Physics, University of Minnesota, Minneapolis, MN

⁶Department of Astronomy, New Mexico State University, Las Cruces, NM

⁷Service d'Astrophysique, C.E.N. Saclay, France

⁸Dipartimento di Fisica, Universita di Catania, Catania, Italy

⁹NASA/GSFC, Greenbelt, MD 20771

WiZard Collaboration: F. Aversa⁹, G. Barbiellini¹⁰, G. Basini⁷, R. Bellotti¹¹, M. Bocciolini⁸, M. Boezio¹⁰, U. Bravar¹⁰, F. Cafagna¹¹, M. Candusso⁹, P. Carlson⁴, M. Casolino⁹, M. Castellano¹¹, G. De Cataldo¹¹, M. Circella¹¹, A. Codino⁶, N. Finetti⁶, T. Francke⁴, N. Giglietto¹¹, R.L. Golden¹, C. Grimani⁶, M. Hof¹², B. Marangelli¹¹, C. De Marzo¹¹, F. Massimo Brancaccio⁸, J.W. Mitchell³, A. Morselli⁹, M.P. De Pascale⁹, P. Papini⁸, A. Perego⁸, S. Piccardi⁸, P. Picozza⁹, M. Ricci⁷, P. Schiavon¹⁰, M. Simon¹², R. Sparvoli⁹, P. Spillantini⁸, P. Spinelli¹¹, S.A. Stephens², S.J. Stochaj¹, R.E. Streitmatter³, M. Suffert⁵, A. Vacchi¹⁰, N. Weber⁴, and N. Zampa¹⁰.

¹Particle Astrophysics Laboratory, New Mexico State University, Las Cruces, NM

²Tata Institute of Fundamental Research, Bombay, India

³NASA/GSFC, Greenbelt, MD

⁴Royal Institute of Technology, Stockholm, Sweden

⁵Centre de Recherches Nucleaires, Strasbourg, France

⁶Dipartimento di Fisica dell'Univ. di Perugia and INFN-Sezione di Perugia, Perugia, Italy

⁷INFN Laboratori Nazionali di Frascati, Frascati, Italy

⁸Dipartimento di Fisica dell'Univ. di Firenze and INFN-Sezione di Firenze, Firenze, Italy

⁹Dipartimento di Fisica dell'Univ. di Roma II "Tor Vergata" and INFN-Sezione di Roma II "Tor Vergata", Roma Italy

¹⁰Dipartimento di Fisica dell'Univ. di Trieste and INFN-Sezione di Trieste, Trieste, Italy

¹¹Dipartimento di Fisica dell'Univ. di Bari and INFN-Sezione di Bari, Bari, Italy

¹²University of Siegen, Siegen, Germany

ZIM Collaboration: W.R. Binns², J.H. Adams³, L.M. Barbier⁵, E.R. Christian⁴, J.R. Cummings¹, G.A. DeNolfo⁷, P.L. Hink¹, M.H. Israel¹, J.F. Krizmanic⁴, R.A. Leske⁷, W. Menn⁹, R.A. Mewaldt⁷,

J.W. Mitchell⁴, S.M. Schindler⁷, M. Simon⁹, S.H. Sposato¹, C.J. Waddington⁶, M.E. Wiedenbeck⁸.

¹Department of Physics, Washington University, St. Louis, MO

²McDonnell Center for Astrophysics, Washington University, St. Louis, MO

³Naval Research Laboratory, Washington, DC

⁴Universities Space Research Association, NASA/GSFC, Greenbelt, MD

⁵NASA/GSFC, Greenbelt, MD

⁶Tate Laboratory of Physics, University of Minnesota, Minneapolis, MN

⁷California Institute of Technology, Pasadena, CA

⁸Jet Propulsion Laboratory, Pasadena, CA

⁹University of Siegen, Germany

TASK 93-12-00 (EGRET)

P. Sreekumar

A significant part of the last 6 months was spent re-examining the long-term sensitivity correction factors for the EGRET instrument. The spark chamber gas in EGRET has been found to degrade with use and it was important to determine if adjustments to the currently applied correction factors (its absolute value as well as its energy-dependence) are necessary for data acquired since the end of 1995. The analysis suggested significant changes in the chamber performance after Sept 1997 when half the spark decks appear to have failed completely. New energy-dependent correction factors for data since then are currently being determined. The determination of the sensitivity corrections have been made extremely difficult by the present reduced operations of EGRET and by its limited field-of-view operation and overall decreased efficiency.

Other routine programmatic activities include carrying out QUICKLOOK analysis of EGRET data during on-going observations, detailed analysis of select EGRET observations, etc.

I have assisted the team lead by R. Hartman to putting together the 3rd EGRET source catalog that is submitted to the Astrophysical Journal Supplement. I was involved with the analysis of CenA data, Mrk501 data of gamma-ray blazars.

Interaction with collaborators from the Univ of New Hampshire (who are also Guest Investigators on the CGRO program) in examining the emission from BL Lac object 2155-304. I also carried out associated XTE and ASCA data reduction. Results from these analysis are being presented at the TeV workshop (Boston Oct 23-24 '98).

Initiated the design of a graphical-user-interface tool (egretdb) to browse the 3rd EGRET catalog. It provides a comprehensive listing of source information based on user-defined criteria. The coding of the tool was carried out by Laura McDonald (RSTX).

Meetings :

A paper on the clear detection of the first radio Galaxy, CenA by EGRET is being presented at the TeV workshop meeting in Washington DC (Jan 1998).

Papers:

Co-author on Mrk 501 paper by Katoake et al (accepted by ApJ)

Co-author on 3rd EGRET catalog by Hartman et al (submitted to APJS)

Currently, I am working on two papers: "High-energy gamma-rays from Cen A" and "Spectral Hardening in gamma-ray blazars during outbursts"

Proposals:

CGRO proposal: (1 approved as PI; 7 approved as Co-I)

XTE proposal: (3 approved as Co-I)
AXAF proposal: (1 as PI) rejected
ASCA proposal: (1 as Co-I) (under review)

Task 93-13-00 – Theory

Natalie Mandzhavidze

1. A review article for the ENCYCLOPEDIA FOR ASTRONOMY

Solar Flares: Gamma Rays.

R. Ramaty and N. Mandzhavidze

We review the theory of gamma ray production in solar flares and present the highlights of the observations and their implications. Specifically:

(i) the gamma ray data show that a large fraction of the released flare energy is in accelerated ions, mostly around 1 MeV/nucleon;

(ii) the accelerated He-3, heavy ion, and relativistic electron abundances are enriched, implying that the particle acceleration is dominated by stochastic gyroresonant interactions with plasma turbulence;

(iii) there is evidence for the enhancement of the abundances of ambient chromospheric elements with low first ionization potentials;

(iv) the observed Li-7 and Be-7 lines, at 0.429 MeV and 0.478 MeV due to alpha-alpha interactions, show that both the accelerated alpha particle and the ambient He abundances are significantly enhanced.

2. A talk presented at the AGU spring meeting (May 26-29, Boston):

Solar He Abundance from Gamma Ray Spectroscopy

N. Mandzhavidze, R. Ramaty.

The main highlight of this work is a discovery of high helium abundance ($\text{He}/\text{H} > 0.1$) in the subcoronal regions of the solar atmosphere.

3. Currently we are working on the improvement of our solar flare gamma ray line production code which now will include the gamma ray lines produced by accelerated He³. It will be possible to observe these lines with high resolution germanium detector that will be flown on the HESSI mission. This will allow us to understand the mechanism of particle acceleration in certain solar flares (so called impulsive flares), which exhibit a huge (1000 fold) enhancement of the accelerated He³ isotope relative to He⁴.

Task 93-14-00 – Mirror Development

Chan, Kai-Wing

In this report, I summarize my work on the development of x-ray telescopes for the project ASTRO-E. The ASTRO-E mirror team consists of the following scientists: Dr. P. J. Serlemitsos with GSFC, Drs. Wilhelm Mandl, Yang Soong and myself, all with USRA. Dr. Mandl left for another position at the end of September.

Development of ASTRO-E telescopes and my contributions:

Major goals for ASTRO-E telescopes this year are: (1) to deliver all the XIS (X-ray Imaging Spectroscopy) telescopes to Japan; (2) to conclude on the coating of the fifth telescope (XRS); and (3) to continue studying the feasibility of direct replication of multilayer coating; (4) to continue to develop new processes for better angular resolution. Multilayer coating is not to be used on any of the ASTRO-E telescopes. If new material is to be used, the mono-layer coating of the XRS telescope is going to be with platinum.

This telescope is to be delivered to Japan next January. My contributions in these efforts have mainly been in areas (1) and (2).

(1) Production and delivery of the telescopes with gold-coated reflectors. Production of monolayer-replicated foils with gold for ASTRO-E is going on in earnest. Yang Soong and myself shared the responsibility of overseeing the production. The management of the production of foils is headed by Yang Soong while I concentrate on the quality control and metrology of finished foils. The actual production is carried out by six full time and one half time technicians, 2 full time engineers. A Goddard staff, Curtis Odell, acts as our lab manager and also provides much technical support and resources.

The delivery of the telescopes are on schedule. We delivered the second telescope in May, the third in July, repaired the first telescope which failed the vibration in Japan and delivered it in September. We are now close to start assembly of the reflectors, which are expected to be completed by October 16, in the telescope housing for the fourth XIS telescopes. The fourth telescope is scheduled to be delivered to Japan in November.

In these efforts, as before, Yang Soong and I oversee the production. Again, basically, Yang Soong takes care of the daily production processes while I am responsible for the metrology programs. The metrologies include daily optical examination of finished reflectors, which is done by a full time engineer, and other surface examination such as linear profiling with an infrared scanner, 2-Dimensional surface profiling with an optical interferometer, and x-ray reflectivity with an x-ray reflectometer. We are about to complete the installation of a new, more powerful, linear scanner which will allow us to scan

surface with widely different roughness. The X-ray reflectometry was carried out by Wilhelm Mandl. Upon his departure, it is now taken up by me.

I am also responsible for the final assembly of the telescopes, after the quadrants are prepared and tuned by Yang Soong and Peter Serlemitsos. I am responsible for the overall assembly of the telescopes, the optical tests on the telescope as a whole, preparation and oversight of vibration tests which are now done in Building 7 of GSFC instead of in Japan, and final optical tests before delivery. A report was prepared for each telescope.

(2) Platinum coating for the fifth telescope.

The fifth telescope to be delivered to Japan will be different. This system will have a microcalorimeter as the detector, a shorter focal length, and a different coating for enhancement of response at higher energies. Original ideas on the coating includes direct deposition of iridium over gold-replicated foils, deposition of platinum over replicated foils and direct replication of with platinum. The effort was leaded by Dr. Y. Ogasaka, who is now at Nayoga University, and I was charged with this responsibility after his departure. To avoid any possible delay in schedule in the development of the needed technology, I pushed along two fronts in the issue:

(a) to carry out a systematic studies on the feasibility of direct platinum replication which seems to fit our current set up best;

(b) to quickly establish a second line of production which has been under consideration and preparation for a long time.

The study was conducted by myself with the assistance of a technician, from July 15 to September 3. The findings are as follows. Conditions for platinum replication were determined. The reflectors were first found to be thermally unstable but is stablized with an extended schedule of epoxy curing. Platinum films on glass were also found to be marginally unstable against large volume of moisture but no such instability was found after replication. Preliminary measurement of x-ray reflectivity shows excellent result but a more extensive confirmation is needed. This is delayed due to the departure of Wilhelm Mandl and the responsibility is now assigned to me. I completed a report on the basic studies. We are still in the process of decision for a platinum replication. Addition studies on the stability and surface roughness will aid the risk-assessment.

On the preparation of a second line of production for platinum replication, the first preparation meeting was held in May. The completion was targeted at October 1. As of today (October 12), the new facility is partially operational but a full production line is not up yet due to some equipment difficulties. Targeted platinum starting

date is October 19. I regret to report that this has not been managed as well as it should have been.

(3) Multi-layered reflectors.

This is one of our major efforts to go beyond ASTRO-E. The development was originally carried out by Yashushi Ogasaka, and later by Wilhelm Mandl. Since October 1, it is taken up by me and will be my major task in the next months. Preliminary investigation supports direct replication with multilayers. Similar effort are undertaken elsewhere, especially in Japan, for the InFocus (also a Goddard-Japan collaboration) and other missions. It seems that we have a better progress at Goddard and are to replicate directly with more than 30 bi-layers over large area. Major investigations, however, still needed to be taken to define the processes and, if successful, to transfer the research concept to production. A difficulty in such production, for example, even with successful replication processes, is the extensive care and time to make even a single reflector.

Projected development and task:

Future development for ASTRO-E includes delivery of the 4th and 5th telescopes and production of spare quadrants. This will take us to the end of April, 1999. I anticipate similar division of labor in these efforts. Research must also include new processes of foil-making in order to better the angular resolution to sub-arc-minute x-ray astronomy. This is particular relevant as more expectation is now on this approach with lightweight foil telescope in x-ray astronomical imaging. We are now continuing to understand the limits to sub-arc-minute telescope. I participate to better define and quantify our reflectors. In particular, I am excited to see to the completion of the setting up of the aforementioned new scanner, which should allow us to define the large-scale 2-Dimensional surface of our foils. My immediate research also includes the development of multilayer reflectors, as mentioned above.

Reports prepared for review meetings and submission to GSFC Project Office:

- (1) "Performance of ASTRO-E XIS Mirror #2 in Vibration test". May 10, 1998. (Prepared for Project Office's Pre-Shipments Review held on 5/10/98).
- (2) "Failure Analysis of Mirror 3 (T1) in Vibration". July 20, 1998.
- (3) "Characteristics of Mirror 3 (T1) in Optical Wavelengths Before and After Vibration Tests (July 27-28, 1998)". July 31, 1998.
- (4) "Brief Report on the Studies in Platinum Replication". September 4, 1998.

(5) "Characteristics of Mirror 3 (T1) in Optical Wavelengths Before and After Vibration Tests (September 2-3, 1998)".
September 9, 1998.

Task 93-14-00 – Mirror Development

Soong, Yang

We are in the final phase of delivering the Astro-E mirrors, of which three have been sent to Japan as scheduled, one will be assembled and be sent over in November. The one for XRS detector with a slightly shorter focal length will be manufactured in the next three months and expected to be finished around February 1999, which is almost exactly one year before the scheduled launch.

Planning for the next generation X-ray imager is also underway. We are expecting higher sensitivity, better image spatial resolution, and much improved detector energy resolution. They are translated to a four-times collecting area, a quarter minute of arc resolution, and a 2eV energy resolution, which pose a real challenge to the instrument builders. The quarter minute of arc image quality is essentially the theoretical limit of the conical approximation of the Wolter type I geometry. Over the years, we have been able to reduce the surface roughness by an order of magnitude through the technique of epoxy replication. The outstanding errors are geometrical error of the foil and the alignment error of a group of foils in the housing. The former one can also be attributed to two kinds of errors. First of all, it is due to the geometrical error of the foil substrate, currently, of aluminum. This error also has two terms, namely, one is the figure error along the optical axis, which causes the image to spread radially as well as azimuthally, the other is the roundness error, which in turn causes the image to broaden. These errors can be reduced through better forming of the substrate, such as using higher specific strength material that can hold the figure better while retaining the conformability to a good figure. Secondly, the surface of which the substrate is going to replicate off has to be improved in geometry, yet, at the same time, retains its smoothness. It is easy realize in theory, but very difficult in practice, unless a good amount of financial support is to be expected. The alignment error is more of a illusive problem, since it involves parameters which can not be easily quantified, such as how much the foil would be distorted under how much of the pressure that a alignment hardware would exert onto the foils, the gravity effect on the foil causing it to distort, etc. We are working on all these errors diligently, since the image quality can only be improved by reducing these errors simultaneously.

The broadening and enhancing the higher energy of the energy response of the mirrors are also under study. Using platinum, which is material of higher mass density, instead of gold as the reflecting surface, is to enhance the energy response by about 25%. The study is almost complete. We are going to implement this method to produce the mirror for the XRS detector. On the other hand, using multilayering of high and low atomic number material in sandwich

form would make reflection of even higher energy photons off the surface possible. These X-ray photons interfere through reflection off each individual layer. This will be applied to a future high altitude balloon flight to receive photons with energy above 20keV.

Task 93-20-00 – CGROSSC

Barrett, Paul

A. Programmatic Work

1. COMPTTEL Archive

As noted in the last reporting period, I spent about 50% of my time working on a project to FITSify and archive the Comptel data. Much of the software development work was completed during the 1st quarter of 1998. The expected completion date was 1 June 1998, but the project was delayed by several weeks while waiting for approval by the OGIP FITS committee, by a two week observing trip to Australia in late June, and by some small errors found in the archiving process. So the more than 30 GB of data were not fully archived until about the first week of August 1998. Additional work to make the archived data visible via W3Browse is basically done as well as documentation about the archiving process.

2. CGRO Proposals

Some work was done to maintain the Remote Proposal Submission software and to assist those proposing for Cycle 8 of CGRO proposal period.

3. CGRO Help

I am still the primary contact for the CGRO help-line. Though requests tend to arrive in groups of 3 or 4, I have on average about 3 request per week.

4. Y2k Verification

In late August we were informed by the LHEA that CGRO must do an end-to-end Y2k verification test of the archival data. This task has been initiated and most of the preparation for the testing is in place. I am in charge of verifying the Comptel data. We are now awaiting delivery of data from PACOR which is expected about mid-November. So little progress will be achieved until then.

5. Termination of Employment

I have been given my termination notice at the COSSC and have less than six months to complete my programmatic work.

B. Research Work

1. Soft X-ray Luminosity Function of AM Herculis Binaries.

A paper is still in preparation on this subject. Programmatic activities and proposal writing has limited the time that I am able

to spend on this, though some good progress has been made during the Summer.

2. Identification of 6 White Dwarfs in the ROSAT archive.

A paper describing these results is still in preparation.

3. Optical and radio observations in Australia

In the latter two week of June 1998, I made an observing trip to Australia to make simultaneous X-ray and optical observations of quasi-periodic oscillations in AM Herculis stars.

Unfortunately, our 3 three night of telescope time were rained out. The RXTE observation proceeded as normal. In addition I had two observing periods at the Australia Telescope Compact Array facility to observe RE0317-854, a proposed 2.2 MeV gamma-ray source. Unfortunately, no radio source down to 0.3 mJy was detected at this position, making it unlikely this star is the gamma-ray counterpart.

4. AXAF, RXTE, HST, and LTSA proposals.

I was co-investigator on 3 AXAF proposals. Though all were ranked within the top 30%, only one of them was accepted.

I fared much better on the two RXTE proposals of which I was principal investigator. Both of these proposals were accepted, one target list was fully scheduled and only a partial list for the other proposal was scheduled.

I was also a co-investigator on an HST proposal. Results from the peer review have not yet been announced.

I submitted a proposal for a Long-Term Scientist Award in early May. This proposal was not accepted.

5. I presented a talk at the 2nd Cape Magnetic Cataclysmic Variable Workshop in Annapolis, Maryland in mid-July 1998.

Task 93-20-00 – CGROSSC

Bridgman, W. Thomas

Project Support Accomplishments:

The revised OSSE low-level spectral data pipeline is now fundamentally operational. There continue to be bug fixes and adjustments. About 7% of the currently archived datasets have problems in the archiving process and need to be examined in further detail. The interface with the HEASARC W3Browse database is fully functional. As a quality-control check, I download 1-2 observations per week and run them through the process of raw-download to a model-fitted spectrum. I'm continuing to monitor and adjust this process as the archive is rebuilt. Work on the high-level data pipeline is continuing and I expect it to go online in the next few weeks.

I'm continuing work with Mark Strickman of NRL on the OSSE detector response matrix generator FTOOL. I am working with Cathie Meetre on preparations for end-to-end tests of OSSE data pipelines for Y2K validation.

I worked on proposal target validation for CGRO cycle 8 but have since been relieved of this responsibility. I also managed updating various reports for CGRO targets of opportunity but this recently has been handed over to others as well.

I wrote up an introduction to the OSSE portion of the CGRO data archive for the HEASARC journal *Legacy*. I also converted the OSSE Guest Investigator Guide to HTML for web publication. A number of other OSSE documents are now available on the web as PostScript.

I am continuing some support on OSSE analysis for a student of Edison Liang at Rice University. I've also processed three other requests for OSSE data, public & proprietary.

Outreach Activities:

I've answered eleven Ask_Astro questions (I'm listed as a resource for answering questions on several topics - black holes & relativity) and seven questions through my STELLAR site. I did presentations on Astronomy Day, 1998 (May 2), "Astronomy on the World Wide Web" and "The Solar Eclipse from Curacao, February 26, 1998". I also staffed the LHEA Outreach booth display at NASA HQ on May 5. I did a talk on GRO at the Greenbelt Astronomy Club, September 24, 1998.

Priorities for the Next Six Months:

My priorities for the next six months include (1) Revised High-Level spectral data pipeline will be going on-line in the next few weeks. (2) Y2K testing and validation of archive pipelines, etc. (3) Complete FTOOL to generate an OSSE detector response matrix for use by XSPEC. (4) Correct the aforementioned problems in the low-level spectral data pipeline. (5) Completion of answers to referee inquiries on Cygnus X-1 paper. This has

involved some serious reworking of the results. (6) Installation of IGORE v7.5 at COSSC. (7) Repair of OSSE low-level pulsar data pipeline – this task definitely cannot be accomplished in the time available so will probably be shelved.

Task 93-20-00 – CGROSSC

Shrader, Chris R.

USRA/CGRO-SSC & Integral Spectrometer SW development Team

CGRO Guest Investigator Program: A large amount of activity was devoted to conducting the Cycle-8 peer review which occurred in July, 1998. New strategies and policies endorsed by the GGRO Users Committee for optimizing the scientific output of the mission in an environment of shrinking resources were employed.

A detailed account of the peer-review outcome was presented to the CGRO Users Committee in August.

In addition, a large effort went into database preparation, software testing, and briefing of committee members for the Cycle-8 Timeline Committee meeting in August.

Routine Guest Investigator inquiries, too numerous to list, were handled. Subjects included instrumentation technical details, program policies and procedures and the proposal evaluation process.

Project Support: The scientific section of the CGRO proposal to the NASA HQ Senior Review Committee was drafted and distributed to the CGRO Users Committee for feedback. A revised version was drafted and delivered (by hand by me!) To NASA Headquarters. Additional support, such as preparation of view-graphs and strategy discussions with the oral-presentation team were carried out.

Various statistics regarding the CGRO Guest Investigator program were supplied upon request to NASA Headquarters and the Project Scientist.

Maintenance of the CGRO-SSC GI Program database continued.

CGRO-SSC Group Leader Activities: Various internal CGRO-SSC organizational meetings were held to coordinate the various ongoing activities. Some forthcoming reductions in the CGRO-SSC staff, and strategies for minimizing the impact of these losses were discussed.

Integral Spectrometer Scientific Software

Development: Weekly team meetings with the ATR, and daily informal meetings with USRA task personnel were conducted.

Plans for modifying the XSPEC analysis software for use with the Integral Spectrometer (SPI) further developed. Periodic meetings with the relevant HEASARC personnel were established, and preliminary tests based on simulated data were carried out. Significant problems in the development of generation of the instrument response matrices were resolved.

Participation in several Integral/SPI collaboration meetings occurred during the reporting period. Overviews of the GSFC activities were presented, and strategies were established for dealing with a number of technical details, such as agreement on data file formats for count spectra and spectral and spatial response matrices.

Numerous correspondences with the ISDC were conducted, notably in support of GSFC's first major software delivery.

Plans for support of Integral-related activities at the forthcoming AAS meeting were made.

Sub-tasks for part-time support on the instrument mass-model development and auxiliary software development were established (mass-model) or initiated (SW).

Scientific Research: Three articles, two as first author and one as second author, were accepted for publication in the *Astrophysical Journal*. A fourth article (third co-author) has been submitted. Topics included X-ray Nova, Be X-ray Transients Quasars.

An additional research-related activity involved participation (through invitation by NASA) in the Cycle-1 FUSE Guest Observer Program scientific peer review.

Other LHEA Activities: Activities as co-chair of the Monday seminar series, and as a member of the Tuesday seminar committee meeting were continued.

Task 93-20-00 – CGROSSC

Ken Watanabe

Compton GRO Science Support Center (COSSC)

- *Wrote part of HEASARC Journal (LEGACY) article about CGRO.
- *Attended the 192nd Meeting of the AAS in San Diego as an exhibitor for the CGRO & GLAST booths.
- *Made a FTOOLS for the BATSE burst data bcmppha -- Converts a CGRO/BATSE TYPE II trigger file to a TYPE I pha file & enables us to use XSPEC to analyze the BATSE burst data.
- *Made a BATSE Pulsar Analysis Tool on the BATSE web pages LCP (Light Curve Plot) -- enables users to plot light curves of the BATSE pulsar data interactively
(<http://coss.c.gsfc.nasa.gov/coss/batse/hilev/perl/idl-lcp.html>).
- *Attended the GLAST Workshop (September 8 - 10).
- *Working with the BATSE PI team for Y2K tests.
- *Attending the GLAST team meeting weekly.

Others

- *Proposal for the GREET (Gamma-Ray Extended Emission Telescope) proposal for NASA's UNEX (UNiversity-class EXplorers) program. (PI: M. Leventhal (UMD), Co-Is: L. Cheng (UMD), R. Kroeger, M. Strickman (NRL), N. Gehrels, B. Teegarden, J. Tueller (GSFC), J. Naya, S. Barthelmy and K. Watanabe (USRA/GSFC)) (Submitted April, 6, 1998) (Rejected September, 1998).
- *Proposal for NRA Mission Concepts for ULD (Ultra Long Duration) Ballooning: "A Gamma-Ray Spectrometer for the Measurement of Diffuse Nuclear Lines" PI: Tueller (GSFC), Co-Is: R. Kroeger (NRL), M. Leventhal (UMD), J. Naya (USRA/GSFC), D. Palmer (USRA/GSFC) and K. Watanabe (USRA/GSFC), (Submitted June, 15, 1998), (Rejected September, 1998).

Papers & Conference Participations

- *Paper: "THE CONTRIBUTION OF SUPERNOVAE TO THE COSMOLOGICAL MEV GAMMA-RAY BACKGROUND", K. Watanabe (USRA/GSFC), D. H. Hartmann, M. D. Leising and L. -S. The (CLEMSON Univ.), presented at the 192nd Meeting of the AAS (June, 98 in San Diego).
- *Paper: "CONSTRAINTS ON ASSOCIATION OF SINGLE-PULSE GAMMA-RAY BURSTS AND SUPERNOVAE", J.P. Norris

(GSFC), J.T. Bonnell, and K. Watanabe (USRA/GSFC), Submitted to ApJ (also astro-ph/9807322).

*Abstract: "CHASING THE ASSOCIATION OF SINGLE-PULSE GAMMA-RAY BURSTS AND SUPERNOVAE", J.T. Bonnell (USRA/GSFC), J.P. Norris (GSFC) and K. Watanabe (USRA/GSFC), Submitted to Gamma-Ray Bursts in the Afterglow Era (November 3-6, 1998 in Rome, Italy).

*Paper: "COSMIC CHEMICAL EVOLUTION AND THE MEV GAMMA-RAY BACKGROUND FROM SUPERNOVAE", D. H. Hartmann (CLEMSON Univ.), K. Watanabe (USRA/GSFC), M. D. Leising and L. -S. The (CLEMSON Univ.), presented at Nuclei in the Cosmos V (Volos, Greece), Submitted to Proceedings edited by N. Prantzos.

*Paper: "STUDYING THE HIGH-ENERGY GAMMA-RAY SKY WITH GLAST", T. Kamae (U. of Tokyo), T. Ohsugi (Hiroshima Univ.), D.J. Thompson (GSFC) and K. Watanabe (USRA/GSFC) (on behalf of the GLAST Collaboration), presented at the 32nd COSPAR Scientific Assembly, Symposium E1.1 Broad Band X-ray Spectra of Cosmic Sources (Nagoya, Japan), Submitted to Advances in Space Research.

*Paper: "THE DIFFUSE GAMMA-RAY BACKGROUND FROM SUPERNOVAE", K. Watanabe, (USRA/GSFC), D. H. Hartmann, M. D. Leising and L. -S. The (CLEMSON Univ.), Submitted to ApJ (also astro-ph/9809197).

Task 94-07-00 – XTE-SOF

Corbet, Robin

I am continuing to prepare for further reductions in the SOF staff. The SOF may soon be operating (at least for a temporary period) at a level of 4 operations people including myself. This is down from 6 in my previous report and 12 at the peak. It is hoped to hire one new person in the near future.

I anticipate, however, that, even at this very low staffing level, most services can still be maintained at close to their earlier levels. This is achieved primarily through removing the monitoring functions that initially formed a large part of the SOF work and has now been replaced through the automation scheme that I envisaged. Some further enhancements may also be possible through use of spacecraft operations staff and/or improvements to software onboard the spacecraft.

During this period operations have continued with very few problems and a large number of target of opportunity observations of exciting new targets have been performed. The rapid response of the RXTE SOF to new targets is still essentially unmatched by other satellites. Plans are also being developed to continue to improve our rapid response capabilities still further.

Preparations are now underway for the start of the fourth round of RXTE observations (AO4) and a large fraction of AO3 has been completed.

Swift

I completed my simulations for the Swift MIDEX proposal (Gehrels/White) and the proposal has now been submitted. I also participated in, and made presentations at, a number of the Swift team meetings. The successes of the RXTE SOF have been viewed as useful for guiding how Swift operations should be carried out.

Scientific Research

Refereed Paper:

“Evidence for a very slow X-ray pulsar in 2S0114+650 from RXTE all-sky monitor observations,” R. H. D. Corbet, J. P. Finley & A. G. Peele, 1998, *Astrophys. J.*, in press.

Previously submitted and now published:

“A multi-wavelength campaign on gamma-Cas. I. The case for surface X-ray flaring,” M. A. Smith, R. D. Robinson, & R. H. D. Corbet, 1998, *Astrophys. J.*, 503, 877.

“ASCA X-Ray Observations of Gamma Cassiopeiae,” S. Kubo, T. Murakami, M. Ishida, & R.H.D. Corbet, 1998, PASJ, 50, 417.

IAU Circulars

“XTE J1855-026,” R. Corbet, 1998, IAUC 6927.

“XTE J1906+09,” T. Takeshima, R.H.D. Corbet & J.H. Swank, 1998, IAUC 7008.

Proposals

All four of my RXTE AO4 proposals were accepted. (I am also a Co-I on several other RXTE proposals).

I submitted one ASCA AO7 proposal the result of which is not yet known.

Education

My student at Penn State (Brian Thomas) finally submitted his Ph.D. thesis and passed his oral defense. (I also participated as the only non-Penn State member of the thesis committee). Some corrections to the thesis are all that is now required.

I am working with Prof. Phil Charles, head of the Oxford University astrophysics department, to have some of his graduate students visit GSFC and work on some of our collaborative RXTE projects. The students would probably be supported by some of my RXTE guest investigator grants via the USRA visitor scientist contract with some additional funding from Oxford.

Miscellaneous

During periods of absence of both Jean Swank (RXTE Project Scientist) and Frank Marshall (RXTE SOC Director) I served as nominal “project scientist” for RXTE with immediate responsibility for e.g. decisions on Target of Opportunity observations.

During this period I reviewed papers for three major journals:

Monthly Notices of the Royal Astronomical Society

Astronomy and Astrophysics

Publications of the Astronomical Society of Japan

I also participated in the NASA Astrophysics Data Program review.

I am collaborating with several researchers in Japan on ASCA observations of many new X-ray pulsars in the Small Magellanic Cloud.

Task 94-07-00 – XTE-SOF

Takeshima, Toshiaki

Position Requirements:

1. Monitoring the science output at RXTE operation room.
2. On-call duty
3. Operation/Analysis Software
4. RXTE WWW Pages
5. RXTE Gamma-Ray Burst Observation
6. Science with RXTE observations
7. Collaborating works

Evaluation Factors:

1. Taking care of realtime monitoring of scientific output from RXTE at the operation room of RXTE from 09:30 to 18:30 every Tuesday and Friday as a duty scientist of RXTE, who is responsible not only for currently going observations but also responsible for the evaluation of TOO request and TOO alert from RXTE All Sky Monitor.
2. Being "on-call duty scientist" for a week out of every other weeks. On-call duty scientist is responsible to making decision for some change in RXTE observations. On-call duty scientist is paged by beeper even at midnight.
3. Being responsible for many of software running at RXTE SOC (Science Operation Center). As the decrease in number of stuffs due to shrinking budget, many of tasks converted to semi-automatic process which is done by programs/scripts. I wrote many of such programs/scripts.
4. Maintaining couple of WWW pages of RXTE, which contribute to publicity of public RXTE data, to planning and decision for, TOO observation, and to science monitoring at RXTE SOC.
5. Now we know that afterglow of Gamma-ray burst (GRB) is observable in X-ray energy band. But it decays quicker than the fastest response time of RXTE TOO with normal replan method (~7 hrs). In collaboration with BATSE team, RXTE/ASM team, BeppoSax team, and ASCA team, we have been performing quick response observations for GRB and establish the procedure without threatening the safety of the RXTE satellite. The averaged response time is about 3 hrs from burst time.
6. Some of TOO observations require quick analysis at RXTE SOF. I've carried out couple of these tasks.

7. GRB chase with RXTE is being done with collaboration with BATSE team, ASCA team, and BeppoSAX team. Recent TOO observations (SGR1900+14, XTE J1748-288) simultaneously with ASCA were carried out under collaboration with ISAS and RIKEN in Japan.

Primary Accomplishments:

1. Science monitoring is time consuming and occasionally boring, while it's very important to prevent satellite and/or payloads troubles. As I think fundamentally I'm paid for this duty, I believe I'm doing what I'm expected to do.

2. I'm always carrying my pager, but seldom beeped except for GRB chase (see 5.).

3. Reconstruction of ASM data processing system in RXTE SOF required much amount of revise to our once established software. Most of these revise was done by Brian Thomas and me.

Due to the shrinking budget of RXTE, number of staffs for RXTE is decreasing. Being prepared for the time I leave RXTE SOF, I've revised many of Web pages (TOO information pages, Short Term Schedule pages, ASM light curve pages, PCA HV on/off history pages, etc.) to make them almost automated.

4. The page I'm maintaining give useful information to RXTE guest observers and also potential guest observers. The total number of access to these pages exceeds 100 par day in average.

5. RXTE project of GRB chase started March 1997. At present time, only Dr. Frank Marshall and I can make quick observation of GRB within about 3 hrs, which procedure is established many tests and trials by me with helps of XTE MOC (mission operation center) staffs and SOF staffs. Whenever GRB that satisfies certain criteria is reported from BATSE team, I'm paged even if midnight. On call duty is every other week, but this job has no holiday.

6. In these six months, we submitted 8 IAU Circulars which includes the discovery of pulsations from XTE J1855-026 and XTE J1946+274, determination of the position of new transients, some of which enabled the discovery of counter part in other wavelength.

7. RXTE observations of SGR 1900+14 during the recent active period of this soft-gamma ray repeater in August confirmed its 5.17 second pulsation discovered by ASCA previously. Our results triggered another ASCA TOO observation simultaneously with RXTE. Without our information ASCA might have missed the source activity. (They changed the observation schedule according to our information.)

Papers Published or Accepted for Publication:

IAUC 7016 "XTE J1946+274 AND 3A 1942+274" T. Takeshima, GSFC/USRA; and D. Chakrabarty, MIT; Refined position of the transient which suggests the source is revived Ariel 5 transient.

IAUC 7014 "XTE J1946+274 = GRO J1944+26" D. A. Smith, MIT; and T. Takeshima GSFC/USRA; Report of transient and discovery of pulsation

IAUC 7008 "XTE J1906+09" T. Takeshima, R. H. D. Corbet, GSFC/USRA; and J. H. Swank, GSFC; 89-sec pulsation was serendipitously detected during the RXTE observation of SGR 1900+14. The source was previously reported from also RXTE observation of SGR 1900+14.

IAUC 7003 "SGR 1900+14" C. Kouveliotou, MSFC/USRA; T. Strohmayer, GSFC; T. Takeshima, GSFC/USRA; J. H. Swank, GSFC; and P. Woods, Univ. of Alabama; RXTE detection of 5.17-sec pulsation from SGR 1900+14.

IAUC 6998 "XTE J1710-281 = 1RXS J171012.3-280754" C. B. Markwardt, NRC/SGFC; F. E. Marshall and J. Swank, GSFC; and T. Takeshima, GSFC/USRA; Refined position and energy spectrum of new transient.

IAUC 6958 "XTE J2123-058" T. Takeshima, GSFC/USRA; and T. E. Strohmayer, GSFC; Refined position and proposing LMXB nature from the detection of X-ray bursts.

IAUC 6904 "XTE J1855-026" F. E. Marshall, GSFC; and T. Takeshima, GSFC/USRA; Discovery of pulsation and the refined position.

IAUC 6855 "XTE J0421+560" D. Smith and R. Remillard, MIT; J. Swank, GSFC; T. Takeshima, GSFC/USRA; and E. Smith GSFC/RSTX; Discovery of very bright new transient with RXTE/ASM.

Other Collaborative Activities:

F. Nagase, T. Dotani, and K. Mitsuda (ISAS) on "time variability of X-ray binary pulsars"

T. Kotani (RIKEN); and T. Dotani & F. Nagase (ISAS), on "New Jet Source XTE J1848-288";

T. Murakami, & F. Nagase (ISAS); A. Yoshida, & N. Kawai (RIKEN); and N. Shibasaki (Rikkyo Univ.) on "Soft Gamma-ray Repeater SGR 1900+14"

C. Robinson & C. Kouveliotou (MSFC); L. Piro (IAS-CNR); T. Murakami (ISAS); and A. Yoshida (RIKEN) on "Chase of afterglow from gamma-ray bursts"

TASK 96-02-00 – GLAST/GTOTE

Alex Moiseev

Technical Report covering a period from April 01 to September 30, 1998

1. The Gamma-Ray Large Area Space Telescope (GLAST):

- Completed baseline design of the Anticoincidence Detector (ACD).
- Performed Monte Carlo simulations on the backplash effect; obtained expected performance of GLAST for different configurations of ACD.
- Completed preliminary comparative analysis of the '97 ACD beam test results with Monte Carlo simulations; obtained results raised the questions to be explored more carefully.
- Developed the requirements and conceptual design of ACD for the '99 GLAST beam test including detecting part, mechanical design and electronics

2. Advanced Cosmic Ray Composition Experiment on the Space Station (ACCESS):

- continuation of the detailed Monte Carlo simulation on the subject of optimization of the ACCESS calorimeter, consideration of alternative designs.
- prepared a presentation at the Workshop "Balloon-Borne and Space-Based Calorimetry" to be held in Texas Tech University on October 22-24

3. Publications for this period:

- H.Matsunaga, S.Orito, H.Matsumoto, K.Yoshimura, A.Moiseev, K.Anraku, R.Golden, M.Imori, Y.Makida, J.Mitchell, M.Motoki, J.Nishimura, M.Nozaki, J.Ormes, T.Saeki, T.Sanuki, R.Streitmatter, J.Suzuki, K.Tanaka, I.Ueda, N.Yajima, T.Yamagami, A.Yamamoto and T.Yoshida "Measurement of low energy cosmic ray antiprotons at solar minimum," Phys.Rev. Letters, 81,18,1998
- J.D.Wells, A.Moiseev and J.F.Ormes "Illuminating dark matter and primordial black holes with interstellar antiprotons," in preparation
- W.Atwood, S.Ritz et al. (GLAST Collaboration) "Beam test of Large Area Gamma Ray Space Telescope prototype components," to be submitted to Nuclear Instruments and Methods

Task 97-02-00 – ASTRO-E

Ebisawa, Ken

Project:

Wrote the "Astro-E Project Data Management Plan". Helped ASCA Guest Observers analyze data through ascahelp e-mail hotline

Developed Astro-E web page
(<http://heasarc.gsfc.nasa.gov/docs/astroe>)

Wrote reports on the recent ASCA GIS instrument status and ASCA scientific highlights on the X-ray binaries toward the ASCA Senior review.

With other member of the ASCA/Astro-E GOF, established the method to create the ASCA telescope responses (ARF) for extended sources through ray-tracing, and wrote a script to run ray-tracing to create calibration files to create ARF. The script will be released to ASCA GOs.

With Astro-E scientists/programmer in GSFC and ISAS, Japan, working on the Astro-E simulation software in the FTOOL scheme.

Science:

Visited Dr. Phillippe Durouchex at Saclay in Paris in June, and gave a seminar on the energy spectra of Galactic Black Hole Candidates

Participated in the workshop on High Energy Processes in Accreting Black Holes in July in Sweden, and gave an invited talk on the energy spectra of Galactic Black Hole Candidates

Submitted an XTE AO4 proposal, "Spectral variation of the black hole candidate GX339-4" (accepted).

Submitted an ASCA AO7 proposal, "1E1024.0-5732 -- X-RAY PULSAR OR A WOLF-RAYET STAR?"

Invited Yoshitomo Maeda to GSFC in June and August, and worked on the data analysis of the XTE Galactic Center scan data together.

Invited Mamiko Nishiuchi to GSFC in August, and worked on the ASCA and XTE GRO J1744-28 data analysis together.

Worked with Dr. K. Asai et al. on the paper "ASCA Observation of the Supersoft Source CAL87" (1998, ApJ, 543, L143)

Task 97-03-00 – Detector Technology

John F. Krizmanic

Summary of Work:

1. Orbiting Wide-angle Light collectors (OWL), Ultra-high Energy Cosmic Ray Experiment: As the lead editor of the proceedings of 'The Workshop on Observing Giant Cosmic Ray Airshowers for $E > 10^{20}$ eV Particles from Space', I finished assembling the materials and saw that the proceedings were published this past June. In April, I gave the physics departmental colloquium at the University of Oklahoma in which I discussed the OWL experiment and the related physics. In the physics simulation arena, I have been further developing the OWL detector Monte Carlo. The mechanics of observing an airshower by multiple satellites has been completed and are in a proving stage. Also, I have been mentoring a graduate student at The Johns Hopkins University on developing an airshower generation computer simulation to be used as the event generator for the OWL detector Monte Carlo. This student worked as a summer student this summer, and we are continuing our collaborative effort. I have also been working with mechanical engineers at GSFC to develop a baseline mechanical design for the OWL satellite and for a smaller, balloon-borne instrument known as OWLet.

2. The Gamma-ray Large Area Space Telescope (GLAST): I have been working with physicists, an electrical engineer, and technicians at GSFC in a core team to develop the VLSI, Amplification Specific Integrated Circuit (ASIC) which will function as the front-end electronics for the GLAST CsI calorimeter. The timely development of a fully functional, calorimeter front-end ASIC is critical as it needs to be incorporated in a test beam in 1999. This test beam is to demonstrate the performance of the various GLAST instrument technologies. We have built up the necessary testing infrastructure and have used it to characterize a first generation prototype of the calorimeter ASIC. The second generation prototype was submitted for fabrication and a round of end-to-end circuit simulations was completed to demonstrate the ASIC's performance. We have also been working on fabricating the necessary supporting circuitry and printed circuit boards to be populated with the second generation ASIC once it is delivered to GSFC.

3. Isotope Matter Antimatter eXperiment (IMAX): In order to increase the instrument's acceptance at lower rigidities for the measurement of atmospheric muons, I had incorporated an updated pattern recognition/event reconstruction algorithms into the analysis software. The results did not demonstrate a substantial

increase in the acceptance. Also, a meeting was held with Todor Stanev who will use the measurement of the proton and helium primary cosmic ray composition as an input to his Monte Carlo. Thus, he will predict the flux of muons that should have been measured by IMAX based on his Monte Carlo model.

4. Education/Outreach: I served as a science advisor for two high school teachers this past summer under the GSFC Earth System Science Education Project/Science Ambassador Program. The teachers developed WEB-based science investigations basing these of the experimental measurements provided by the ACE mission. These investigations are to be used by middle and high school teachers as part of their classroom resources.

Future Planned Work:

1. Orbiting Wide-angle Light collectors (OWL), Ultra-high Energy Cosmic Ray Experiment: Work will continue on the further development of the OWL detector/physics simulation. Areas of concentration will include atmospheric modeling to determine light transmission efficiencies and modeling of the focal plane array to investigate to determine the performance of various configurations. I will also begin to quantify the physics capabilities of the OWL mission.

2. The Gamma-ray Large Area Space Telescope (GLAST): The research will be pointed at accurately determining the performance of the second generation ASIC and comparing these measurements to simulated results. To complete this task, computer-based testing procedures will be developed to speed and aid the testing. The goal is to fully understand the ASIC operation and feed this data into a third generation design.

3. Isotope Matter Antimatter eXperiment (IMAX): Work will continue on the atmospheric muon analysis. Once a comparison is made to the simulated predictions of Stanev, work will begin on formalizing these results in a paper.

4. The Isotope Magnet Experiment (ISOMAX): The ISOMAX experiment had an extremely successful flight this past summer. I plan on working with the ISOMAX team to develop the computer-based algorithms needed for data reduction and analysis.

5. Novel Semiconductor Detector Development: The semiconductor/ASIC characterization resources will be updated. Research may begin on investigating the use of diamond as a low-energy cosmic ray particle detector in a collaborative effort with Tycho von Roseninge.

Task 98-01-00 – Space Physics

Baring, Matthew

Cosmic Rays:

In conjunction with Drs. Don Ellison and Steve Reynolds (NCSU), and Drs. Isabelle Grenier and Philippe Goret (CEA-Saclay, Paris), I have been applying the Monte Carlo shock acceleration model to study gamma-ray emission from supernova remnants. The model fully incorporates the non-linear acceleration effects that are crucial to the understanding of SNRs. We have made predictions that can accommodate the constraining Whipple upper limits to EGRET unidentified sources with remnant associations, and have identified the conditions required for gamma-ray bright sources and those for cosmic ray generators.

Dr. Frank Jones (GSFC), Prof. Randy Jokipii (Univ. Arizona) and I have performed a formal derivation of the theorem that states that charged particles in an arbitrary electromagnetic field with at least one ignorable spatial coordinate remain forever tied to a given magnetic field line. Such a situation contrasts the significant motions normal to the magnetic field that are expected in most real three-dimensional systems. This theorem has important consequences for plasma simulations of acceleration of cosmic rays by astrophysical shocks, rendering reduced-dimensionality simulations inappropriate for highly oblique shocks encountered in the heliosphere.

Together with Dr. Frank Jones (GSFC) and Prof. Don Ellison (NCSU), I have developed a model for the acceleration of anomalous cosmic rays (ACRs) at the solar wind termination shock. This model applies our Monte Carlo shock acceleration code to the case of quasi-perpendicular shocks. We found that the observed ACR intensities are consistent with the measured abundances of pick-up ion populations in the heliosphere and the complete absence of any pre-acceleration mechanism for injecting ions into the Fermi process. Diffusion near the Bohm limit is found to provide high acceleration efficiencies so that pick-up ion components are then (and only then) unnecessary to explain the ACR intensities.

Pulsars:

Together with Dr. Alice Harding (GSFC), I have identified a simple physical explanation for radio quiescence in highly magnetized pulsars such as soft gamma repeaters and anomalous X-ray pulsars. This quiescence is expected due to the effectiveness of photon splitting and ground state pair creation in the strong neutron star fields in strongly inhibiting the production of electron-

positron pairs. The boundary for the onset of the suppression of radio emission lies at period derivatives above those of known radio pulsars but below those of the anomalous X-ray pulsars and soft gamma repeaters, thereby defining a clean division between these classes of pulsars. This field is currently extremely topical, and has hit the front page of the Washington post at least once!

Physics of Strong Magnetic Fields:

Dr. Alice Harding (GSFC), Dr. Peter Gonthier (Hope College, MI) and I have investigated the behaviour of the resonant Compton scattering cross-section in supercritical magnetic fields. We have obtained numerical results and approximate analytic forms in the case where incoming photons propagate almost along the magnetic field, and found that Klein-Nishina suppression of the cross-section yields significantly different polarization properties from the "Thomson" regime of subcritical fields. Such computations will be extremely useful for models of strongly-magnetized pulsars and soft gamma repeaters.

Together with Dr. Jeanette Weise and Prof. Don Melrose of the University of Sydney, I have been researching the physics of the process of magnetic photon splitting. We have re-derived analytic expressions for the S-matrix rates and have obtained further significant simplification of the formulation. In special cases, these rates reduce to certain well-known simple forms that were obtained by another technique, the proper-time formalism, and agree with proper-time rates computed by a code developed by Dr. Baring and Dr. Alice Harding. These rates are useful for astrophysical models of pulsars and soft gamma repeaters.

REPORT DOCUMENTATION PAGEForm Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE December 1998	3. REPORT TYPE AND DATES COVERED Contractor Report	
4. TITLE AND SUBTITLE High Energy Astrophysics Research and Programmatic Support (Final Report)			5. FUNDING NUMBERS NAS5-32490	
6. AUTHOR(S) Angelini, L., et al.				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES) Universities Space Research Association (USRA) 10227 Wincopin Circle, Suite 212 Columbia, MD 21044			8. PERFORMING ORGANIZATION REPORT NUMBER 12	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES) National Aeronautics and Space Administration Washington, DC 20546-0001			10. SPONSORING / MONITORING AGENCY REPORT NUMBER NASA/CR-1999-209463	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Unclassified-Unlimited Subject Category: 90 Report available from the NASA Center for AeroSpace Information, 7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This report reviews activities performed by members of the USRA contract team during the six months of the reporting period and projected activities during the coming six months. Activities take place at the Goddard Space Flight Center, within the Laboratory for High Energy Astrophysics. Developments concern instrumentation, observation, data analysis, and theoretical work in Astrophysics Missions supported include: Advanced Satellite for Cosmology and Astrophysics (ASCA), X-ray Timing Experiment (XTE), X-ray Spectrometer (XRS), Astro-E, High Energy Astrophysics Science Archive Research Center (HEASARC), and others.				
14. SUBJECT TERMS Astrophysics; research; observations; data analysis; archive; guest investigator; gamma-ray; x-ray			15. NUMBER OF PAGES 79	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

